Mining Matters for Nova Scotia 2000 - Opportunities for Economic Development

Nova Scotia Department of Natural Resources
Mineral Resources Branch
Report 2000-2

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Program

Monday, October 30, 2000

8:30 a. m. - 7:00 p. m. Registration (Highland level)
8:30 a. m. - 9:00 a. m. Coffee and refreshments
9:00 a. m. - 9:20 a. m. Fall business meeting of the Mining Society of Nova Scotia (MSNS) in Highland Suite 6
10:00 a. m. - 9:00 p. m. Displays open (Highland Suites 7, 8, 9, 10 and 11)
9:30 a. m. - 9:40 a. m. Welcoming remarks (Scott Swinden/Dan Graham)

Note: All talks will be presented in Highland Suite 6

Session 1 - Current Developments in the Nova Scotia Mining Industry (hosted by MSNS)

Session Chair: Howard Donohoe, MSNS

9:40 a. m. - 10:00 a. m.	Stuart Ross, DalTech Campus, Dalhousie University: Improvements to grade-control practices at Georgia Pacific Canada, Port Hawkesbury
10:00 a. m. - 10:20 a. m.	Alex Paris, DalTech Campus, Dalhousie University: The use of cavity monitoring at the Ruttan Mine, Manitoba
10:20 a. m. - 10:40 a. m.	Peter Dwyer, William Alexander and Associates: Are we in a new age of partnerships for resource industries?
10:40 a. m. - 11:00 a. m.	Refreshment break
11:00 a. m. - 11:20 a. m.	Paul Smith, DNR: Meguma gold: then, now and the future
11:20 a. m. - 11:40 a. m.	Manou Akhavi, College of Geographic Sciences: Geological interpretation of northeastern Nova Scotia with Radarsat S2 Beam mode
11:40 a. m. - 12:00 p. m.	Doug Gregory, East Coast Operations Manager, Shell Canada: Aspects of East Coast 3-D seismic exploration
12:00 p. m. - 1:30 p. m.	Lunch break (no scheduled event)

Session 2 - Building a New Economy in Cape Breton Island: Potential Contributions from Mining

Session Chair: Mike Cherry, DNR

1:30 p. m. - 1:50 p. m.	Mike Cherry: Opening remarks
1:50 p. m. - 2:10 p. m.	Phil Finck, DNR: Industrial mineral resources of Cape Breton Island: potential for future economic development
2:10 p. m. - 2:30 p. m.	Dan Kontak, DNR: Overview of the metallogeny of Cape Breton Island with emphasis on the Stirling and Coxheath belts
2:30 p. m. - 2:50 p. m.	Refreshment break
2:50 p. m. - 3:10 p. m.	Bob Boehner, DNR: Windsor Group salt and potash resources, and petroleum geostorage potential in the Strait of Canso region, Inverness and Richmond Counties, Cape Breton Island
3:10 p. m. - 3:30 p. m.	Peter Giles, GSC (Atlantic): Geology of the Carboniferous basins of Cape Breton Island
3:30 p. m. - 3:50 p. m.	Ralph Stea, DNR: Geology of Mesozoic-Quaternary buried valleys on Cape Breton Island: potential for clay, sand and other resources
3:50 p. m. - 3:55 p. m.	Mike Cherry: Closing remarks
3:55 p. m. - 4:10 p. m.	Refreshment break
4:10 p. m. - 5:00 p. m.	**Keynote Address, Richard Grieve, GSC (Ottawa): The terrestrial impact record**
5:00 p. m. - 9:00 p. m.	Reception hosted by the Honourable Ernest Fage, Minister of Natural Resources

Tuesday, October 31, 2000

8:30 a. m. -	Registration

12:30 p. m.
8:30 a. m. - 4:00 p. m. Displays open (Highland Suites 7, 8, 9, 10 and 11)
8:30 a. m. - 9:00 a. m. Coffee and refreshments in poster area

Session 3 - Current Geoscience Research in Nova Scotia
Session Chair: Mike Cherry

9:00 a. m. - 9:20 a. m.	Rick Horne, DNR: Overview of the Southwestern Nova Mapping Program 1998-2000
9:20 a. m. - 9:40 a. m.	Terry Goodwin, DNR: Mercury in till and soil gas, Kejimkujik National Park, Nova Scotia
9:40 a. m. - 10:00 a. m.	Cliff Stanley, Acadia University: Investigations of petrologic controls on trace element concentrations in the South Mountain Batholith, southern Nova Scotia
10:00 a. m. - 10:20 a. m.	Martin Gibling, Dalhousie University: Brines in the Sydney coalfield: remnants of the Windsor Sea
10:20 a. m. - 10:40 a. m.	Refreshment break
10:40 a. m. - 11:00 a. m.	John Calder, DNR: World Heritage designation for Joggins: a flagship project for Nova Scotia's natural resources
11:00 a. m. - 11:20 a. m.	Brian Fisher and Jeff Poole, DNR: From Faribault to digital mapping: accessing GIS databases at DNR
11:20 a. m. - 11:40 a. m.	George O'Reilly, DNR: Base metal potential associated with major faults in central Nova Scotia
11:40 a. m. - 11:50 p. m.	Mike Cherry: Closing remarks
12:00 p. m. - 1:00 p. m.	Meeting of the Association of Professional Geoscientists of Nova Scotia (Highland #6)
12:00 p. m. - 1:00 p. m.	Lunch break (no scheduled event)
1:00 p. m. - 4:00 p. m.	Displays open
2:00 p. m. - 2:30 p. m.	David Comba, Prospectors and Developers Association of Canada: State of mining exploration activity in Canada and around the world
3:00 p. m. - 4:00 p. m.	Workshop, Registry of Mineral and Petroleum Titles: DNR's process of opening closed ground - the Tangier experience
4:00 p. m.	Conference closed

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Geological Interpretation of Northeastern Nova Scotia with Radarsat S2 Beam Mode

by ***M. S. Akhavi***, RS/GIS Faculty, Centre of Geographic Sciences, Nova Scotia Community College, 50 Elliot Road, Lawrencetown, Nova Scotia B0S 1M0; phone: 902-584-2059, FAX: 902-584-721, akhavi@cogs.ns.ca

A seamless mosaic was produced for northeastern Nova Scotia using eight Radarsat S2 Beam mode scenes. Filter enhancement was conducted to remove signal speckles and produce a uniform mosaic. A variety of lineaments and structural features were observed on the Radarsat mosaic, which helped geological mapping of selected sites and interpretation of their geological framework. Specifically, a graben and synform located at the River Denys Basin of Cape Breton are easily identified on the Radarsat imagery. The graben seems to be dissected with deep-seated linear

features.

A "dome-shaped" feature can be delineated on the east side of the synform. This feature is capped with evaporate country rocks. Its structural form, existence in a sedimentary basin, and its cap rock make this structure an ideal target for geological and geophysical field work pertaining to the exploration of potential petroleum deposits.

As well, major faults such as the Hollow Fault in the Antigonish area and the Aspy Fault on Cape Breton Island are readily detectable on the Radarsat imagery. Granitic plutons in the Canso-Guysborough area can be delineated on the imagery due to their shape, smooth texture and medium tone. These features, as well as the metasedimentary rocks which separate them or occur in their vicinity, can be easily detected on the Radarsat mosaic.

This study indicates that Radarsat imagery is very useful for discerning structural features and may reveal the existence of targets suitable for further geological investigation and structural modelling.

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Windsor Group Salt and Potash Resources and Petroleum Geostorage Potential in the Strait of Canso Region, Cape Breton Island

by ***R. C. Boehner***

Nova Scotia has extensive salt resources and a long history of commercial production. The first underground salt mine in Canada opened in Malagash in 1919. Two major salt producers are currently active: the conventional underground mine of Canadian Salt Company Limited at Pugwash and the Sifto Canada Inc. evaporating plant at Nappan. These operations annually produce approximately 0.9 million tonnes with a current production value of approximately $50 million. The bulk of this salt is produced as de-icing salt and the remainder is used as a number of evaporated salt products. Salt deposits are ideal hosts for geostorage due to salt's unique properties of high solubility in water and impermeability at ambient temperatures and pressures. In the early 1980s, ore grade sections of potash (KCl-mineral sylvite) were intersected in the Malagawatch and Orangedale areas located 40 km to the northeast of the Strait of Canso. Only trace to minor potash shows are currently known in the Kingsville, McIntyre Lake and Port Richmond salt deposits. MgCl, a source of Mg metal, occurs in a low-grade intersection of carnallite in the Kempt Head deposit, located 80 km to the northeast of the Strait area; however, like sylvite, the regional distribution has not been established.

Although salt resources in Nova Scotia can be estimated as many billions of tonnes, the economics of extraction, transportation and an extremely competitive market make new mineral developments a rare opportunity. In essence, location adjacent to deep-water shipping is essential for viable export of this mineral commodity. Coincidence with other industrial mineral resources (e.g. limestone, dolomite, clay, sand) and energy resources is a powerful factor in economic development. Halite (NaCl) is a major source of feedstock for the manufacturing and chemical industries, particularly as a source of Cl in the petrochemical industry. Of considerable current interest is geostorage, which offers an alternative use of salt resources, not as a produced mineral commodity but by utilizing the unique solubility and sealing qualities of salt units to dissolve cavities for underground storage. Typically, deep salt resources unsuitable for mineral extraction can be used for storage. The objective of complementary use, in which evaporated salt is produced (e.g. Nappan operation) and geostorage space simultaneously created, is ideal for resource management, but is not always economically practical. Geostorage potential should always be considered in the development of salt resources.

The Strait of Canso area in south-central Cape Breton Island (NTS 11F/10, 11, 14, 15) contains an exceptional convergence of several key factors necessary for both resource and geostorage development. These include: well

developed industrial and energy infrastructure (year-round deep-water shipping capacity supporting vessels up to 350 000 tons), past refining history and current storage facilities, recently developed natural gas and liquids delivery infrastructure, several salt deposits with mineral and storage exploration and development potential within 10 to 25 km, and proximity to future East Coast offshore petroleum and natural gas development projects. Dow Chemical of Canada Ltd. undertook development of two caverns at Port Richmond in the early 1970s, including one structure with an indicated capacity of 391,000 barrels. The McIntyre Lake and Kingsville deposits were proposed to be developed as part of the USA Strategic Petroleum Reserve, which contains approximately 0.6 billion barrels of crude oil, mostly in salt caverns in Texas, Louisiana and Mississippi.

The general advantages of geostorage in salt structures include: (1) cavities can store a variety of products (typically hydrocarbons), including all gases (including compressed air) and liquids with a great range of pressures; (2) low development costs in optimum size and pressure ranges when compared to surface structures (approximately 1/3); (3) highest storage delivery rates when compared with conventional hydrocarbon reservoir alternatives; (4) low surface environment footprint and (5) well established technology and a good safety record. Development issues in the Strait of Canso area include: geologically complex and heterogeneous salt deposits; balancing salt deposit exploration and optimum development planning; balancing resource management as a mineral and/or geostorage cavern; cavern development and recovery; salt and water issues (e.g. the source of dissolution water, and salt water disposal in the ocean). Historic solution mine and geostorage failures have included product loss and explosion due to failure of cavern access casing, inadequate operating/safety procedures, and surface subsidence.

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World Heritage Designation for Joggins: A Flagship Project for Nova Scotia's Natural Resources

by ***J. H. Calder***, jhcalder@gov.ns.ca and ***R. Ogilvie***, Nova Scotia Museum, 1747 Summer Street, Halifax, Nova Scotia B3H 3A6

'But the finest example in the world of a natural exposure in a continuous section ten miles long, occurs in the sea cliffs bordering a branch of the Bay of Fundy in Nova Scotia.' Sir Charles Lyell, 1871

The fossil cliffs of Joggins are one of the world's most famous geological sites, a stature long ago attained. Although Joggins may be Nova Scotia's best candidate for World Heritage designation of a natural site by UNESCO, inscription on the World Heritage list is neither automatic nor is it granted on the basis of past laurels alone, but requires careful documentation, cogent argument, and demonstration of community stewardship and government leadership. A Steering Committee under the direction of the Cumberland Regional Economic Development Agency (CREDA) has made significant progress to this end during the past year. It comprises Mark Boon, Chair, and Don Reid of Joggins, Eric Leighton and Ken Adams of the Parrsboro area, Rhonda Kelly of CREDA, as well as the authors. A new governance model has been drafted, and the size and shape of the committee is expected to change considerably in the future.

Two key aspects of the successful nomination of every UNESCO World Heritage Site are scientific justification and issues of site management. Government of Nova Scotia departments are playing a key role in fulfilling both of these requirements, in concert with the working committee, CREDA and the community. The role of the Department of Natural Resources is to establish unequivocally the justification for Joggins to be inscribed on the World Heritage list, which UNESCO (1972, p. 2) considers to be 'the most crucial aspect of the whole nomination dossier.' UNESCO is explicit in their requirement to adhere strictly to the prescribed format for nomination dossiers submitted to the World Heritage Committee by the country in question. The strength of Joggins's nomination lies largely on three fronts: (1) its role in the history of geology, notably as a proving ground for the geological principles of Sir Charles Lyell in the mid-Nineteenth Century; (2) its fossil record of the 'Coal Age', which is both diverse, equally embracing plants, invertebrates and vertebrates, and pivotal in terms of evolutionary events, notably the earliest reptiles; and (3) the

constant replenishment of exposures, a result of the world's highest tides.

Following a model developed by University College, London, a comprehensive management plan for the site, reflecting the current designation of Joggins as a Special Place but anticipating World Heritage Site status, is being developed by the Nova Scotia Museum with direction from the committee and input from the community. Much of the direction for the current draft management plan has been derived from the work of the River Hebert, Joggins and Area Development Association. The community will continue to contribute an integral part of the planning process, and its involvement is considered by UNESCO to be crucial. If World Heritage Site status is attained, community impact will be tremendous. Public participation in the planning stage will ensure that long-term impact on the community will be positive.

The road to successful World Heritage Site nomination will require commitment and dedication, but will result in a lasting and sustainable legacy for all Nova Scotia, and positive attention drawn to our natural resources.

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Conchostracan Fossils from the Late Triassic Wolfville Formation near Medford Beach, Southern Minas Basin, Nova Scotia

Funded in part by Acadia University and by SHELL UK EXPRO NBU

by ***B. Cameron***, Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0 and ***S. Gould***, Department of Geology and Petroleum Geology, University of Aberdeen, Meston Building, Kings College, Aberdeen, AB24 3UE, Scotland, UK

Fossiliferous blocks of finely laminated, mudcracked siltstones and claystones occur along the coastline near Medford Beach between the Pereau River and Kingsport on the western shores of the Minas Basin, Nova Scotia. Similar rocks were first reported 100 years ago by Haycock (1901) as containing ostracodes. These fossils were re-interpreted as two forms of the conchostracan Estheria ovata (=Cyzicus) by Powers (1916). One of us (Gould) rediscovered these fossiliferous rocks this past summer. Analysis of our new material indicates that there are at least two species of bivalved conchostracans (Crustacea) that we provisionally refer to Cyzicus sp. and ?Cornia sp. They are moderately well preserved as molds and as calcite replacements of the original chitinous exoskeleton and are associated with less common Darwinula-like freshwater ostracodes and fish scales. Although conchostracans and ostracodes have been previously reported from the overlying Blomidon Formation, this is the first report of Cornia from the Fundy Basin. This locality is about 1 km south of Paddy Island where the contact between the Wolfville and Blomidon formations is well exposed.

These fossiliferous rocks are associated with sea cliffs up to 10 m high which expose fluvial channel systems of the upper part of the middle Wolfville Formation. Although no in situ fossiliferous beds were located, similar but discontinuous lithologies are interbedded with sandstones and conglomerates in the adjacent outcrop. Lithologically similar angular intraformational rip-up clasts up to 1 m long occur at the base of thick channel sandstones. The laminated siltstones and claystones were probably deposited in small interfluvial floodplain ponds or abandoned channels that were subsequently reworked after early lithification. These fossil-bearing rocks are interpreted as having fallen from the adjacent outcrop and are not considered displaced beds from the Blomidon Formation, as suggested by Haycock (1901) and Powers (1916). The Blomidon Formation contains different species and genera of conchostracans (Cameron and Jones, 1987).

Cyzicus sp. is the larger and more elongate of the two forms present, ranging (n = 20) from about 4.3 to 10 mm long and about 2.6 to 5.5 mm wide. It has a long, straight hinge line and numerous growth lines. Cornia sp. is subrounded.

convex, ranges (n = 20) from about 1.4 to 4.3 mm in length and about 1.0 to 3.2 mm in width, has fewer growth lines, lacks umbonal growth lines, and often has a short umbonal node or spine. Previously reported occurrences of Cyzicus include the Late Triassic Blomidon Formation of Nova Scotia as well as Late Triassic and Early Jurassic formations in many of the Newark basins in the Eastern United States. Cornia has been reported from Early Jurassic rocks in the Culpepper and Hartford basins in Virginia and Connecticut, respectively. A more comprehensive taxonomic study of the Wolfville and Blomidon conchostracans of Nova Scotia is in progress.

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Amphibian Fossils from the Middle Member of the Early Carboniferous Horton Bluff Formation

Funded in part by Acadia University, Wolfville, Nova Scotia

by ***B. Cameron***, Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0, ***C. Mansky***, General Delivery, Avonport, Nova Scotia B0P 1B0 and ***R. Godfrey***, 159 Dickey Drive, Lower Sackville, Nova Scotia B4C 1T7

Amphibian and fish body fossils and trace fossils from coastal exposures of the Middle Member of the Horton Bluff Formation at Blue Beach and Horton Bluff, Nova Scotia, are being collected, prepared, photographed, catalogued and studied. Our tetrapod specimens come from sandstone and shale of the cyclic, lacustrine/marginal marine(?) Blue Beach and Hurd Creek members, as described by Martel and Gibling (1994), and include femora, tibiae, ?fibulae, phalanges, ribs, and neural spines, as well as a diverse assemblage of footprints and trackways. These fossils occur in shoreline and nearshore facies of these Tournaisian (Early Carboniferous) rocks. The bones are usually isolated and found primarily in sandstone, while the traces are best preserved as convex hyporeliefs on the lower bedding surfaces of sandstone. Associated fish fossils include isolated large rhizodontid (sensu stricto) teeth, jaws, cleithra, clavicles and scales; acanthodian and palaeoniscid remains; unidentified dermal bony armour plates; and the fish trace fossil ***Undichnus*** (=***Undichna***). Rare examples of articulated fish remains include portions of crossopterygians, palaeoniscids and acanthodians.

Although amphibian body fossils are very rare in the Horton Bluff Formation, their footprints represent some of the oldest known vertebrate footprints in North America and may be the best preserved of the Devonian to Early Carboniferous amphibian footprint assemblages in the world. The footprints being studied by the authors indicate that a diverse assemblage of tetrapods existed during the Early Carboniferous in Nova Scotia. The belly-drag trace ***Ctenerpeton*** is reported from the Horton Bluff Formation for the first time.

The occurrence of amphibian body fossils in the Horton Bluff Formation also suggests the presence of a diverse tetrapod assemblage. At least two different kinds of femora are present. One form agrees with supposed "seymouriamorph anthracosaur" femora previously reported from the Horton, but not described, which are characterized by a subrectangular adductor blade and a well-developed adductor crest. A similar blade is also present on the femur of the Late Devonian tetrapods ***Tulerpeton***, ***Acanthostega*** and ***Ichthyostega***. This feature suggests that this unnamed Horton Bluff amphibian has reptiliomorph (anthracosaur) affinities. The other type appears less robust, lacks the well-developed crest, and differs markedly in the distal articular and ventral surfaces. The ribs are robust enough to indicate amphibian affinities. Three toe bones are known, two are articulated distal and penultimate phalanges.

Although older (Late Devonian) tetrapods are known that have many primitive features, mid- to late-Early Carboniferous and later forms are already differentiated into well-known clades. Worldwide, however, no amphibian remains of earliest Carboniferous age, an 8 plus million year gap, are known except from the Horton Bluff Formation, which is dated as somewhat mid-way between these assemblages. Because much tetrapod evolution occurred during this "Tournaisian gap" the Horton Bluff amphibian fossils are significant finds.

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Granite-hosted Mineral Deposits of the New Ross Area, South Mountain Batholith, Nova Scotia: P, T, and X Constraints of Fluids Using Fluid Inclusion Thermometry and Decrepitate Analysis

by ***S. Carruzzo***, Department of Earth Sciences. Dalhousie University, Halifax, Nova Scotia B3H 3J5, ***D. J. Kontak***, kontakdj@gov.ns.ca and ***D. B. Clarke***, Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 3J5, (barrie.clarke@dal.ca)

The 370 Ma peraluminous South Mountain Batholith (SMB) intrudes Meguma Supergroup metasedimentary rocks in Nova Scotia. The New Ross area of the SMB contains polymetallic mineralization (Sn, W, U, Mo, Cu, and Mn) in pegmatite, greisen, and veins directly or indirectly associated with highly evolved fractions of the SMB. Eight mineral deposits from this area have several fluid inclusion types hosted by quartz: (1) monophase liquid (L); (2) monophase vapor (V); (3) aqueous, L-V (4) aqueous, L-rich ± solids; and (5) aqueous, L-rich plus halite. Inclusions have irregular to equant shapes and are pseudo-secondary or secondary. The irregularity and variability of L:V ratios within fluid inclusion populations suggest post-entrapment modifications of inclusions (i.e. necking).

Thermometric data indicate three distinct fluids in terms of salinity: (1) 19-25 wt. % equiv. NaCl (rarely 14-25 wt % equiv. NaCl); (2) 29-43 wt. % equiv. NaCl; and (3) 0-9 wt. % equiv. NaCl. Temperatures of first melting and ice/hydrohalite melting indicate $CaCl_2$ in solution. Proximity of the deposits to Meguma Supergroup metasedimentary rocks suggests that this Ca component may be externally derived. The majority of the low-salinity fluid population has a fluid salinity approximating that of meteoric water. Electron microprobe analyses of artificially decrepitated mounds identify Na, Ca, and K as major solutes, with a continuum in terms of compositions. Other solute components in the mounds are Fe and Ba, and a variety of metals of unknown speciation also occur (Cu, Zn, Fe, Ni). Homogenization temperatures (T_h) range from ca. 80° to 370°C, but for inclusion assemblages the range is 10° to 20° C. Given that the depth of emplacement of the SMB equates to 3 kbar pressure, the pressure-corrected entrapment temperatures are ca. 200° to 550°C. The fluid inclusion data appear to reflect: (1) trapping of mixed Na-K-Ca brines during isobaric cooling in pegmatite and greisen deposits, as indicated by large ranges in T_h; (2) formation of deposits at different ambient pressures (i.e. depth); and (3) mixing of fluids of different reservoirs (i.e. magmatic, metamorphic, meteoric).

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Co-existing Electrum, Bismuth, Galena and Plumbian Bismuth Sulftellurides, Beaver Dam Gold Deposit: Implication for Thermometry of Hydrothermal Veins

by ***A. K. Chatterjee*** and ***P. K. Smith***, pksmith@gov.ns.ca

Arsenopyrite-absent quartz - feldspar - muscovite ± tourmaline veins at the Beaver Dam gold deposit (latitude 45° 04'45"; longitude 62°43'30") in the Meguma Terrane of Nova Scotia contain co-existing electrum, native bismuth, galena, hedleyite, joseite, galenobismutite and bismuthinite. So far as we know, this unusual mineral paragenesis in the Au-Ag-Bi-Te-Pb-S system is unknown in mesothermal lode gold deposits that range in age from Archean to

Triassic. Lack of experimental and thermodynamic data in the multi-component system hinders our understanding of the mineral paragenesis; however, textural relationships and composition of the mineral phases are used to constrain the probable mode of origin.

The sulphide minerals (observed minerals in the Au-Ag-Bi-Te-Pb-S system; i.e. native elements, tellurides, alloys and sulphides of Pb and Bi) occur in five distinct micro-structural settings: (1) as isolated inclusions in silicates, pyrite and scheelite; (2) as linear arrays of inclusions varying from spheres or equant negative crystals to elongated rods along the growth planes in muscovite; (3) as open-space fillings showing extensive development of myrmekitic textures involving more than two mineral phases; (4) as aggregates of minerals in mutual contact with each other enclosed in pyrite; and (5) as clusters of ore minerals with diverse textural relationships.

Electrum occurs as isolated blebs ranging in size from 4 to 45 μm in pyrite and muscovite, as long cylindrical inclusions in muscovite, and as composite aggregates in close association with native bismuth and hedleyite. Rarely, it has micro-inclusions of native bismuth and hedleyite. Silver is the dominant impurity in electrum. The differing silver contents of electrum within a single grain (from 29.8 to 56.4 atom %) and in composite aggregates (from 21.6 to 62.3 atom %) is unexpected. Detailed X-ray mapping of silver in electrum reveals that the high silver regions occur as curvilinear lamellae as 'guest' in the electrum 'host'. Our preferred interpretation is that the observed variations are exsolution features representing metasomatic effects. Previous investigations have documented significant amounts of bismuth (>5.0 wt %) as an impurity in electrum; however, in view of the low solubility of bismuth (<0.4 wt % at 500° C; much lower at low temperature) in gold it is unlikely that bismuth can be incorporated as solid solution in electrum. Instead, the high bismuth content in electrum is probably due to interference from incorporation of micro-inclusions of native bismuth or maldonite in electrum. At the temperature (266-312°C) of mineralization deduced from coexisting native bismuth plus hedleyite, and upper stability limit of hedleyite, the deduced maximum fS_2 for low and high Ag electrum is $10^{-7.4}$ to $10^{-9.3}$ and $10^{-8.9}$ to $10^{-11.2}$ bar, respectively.

The bulk composition of the three-phase mineral assemblage (galena - joseite - hedleyite) in myrmekitic intergrowth lies below the galena - tetradymite join (i. e. higher Bi/Te plus S ratio) in the Pb - (Te plus S) - Bi system. In addition, the exsolved phases are all non-stoichiometric; however, all compositions are co-linear. The colinearity implies that the mineral phases are cogenetic and are not of replacement origin. The bulk composition (plumbian sulftelluride) does not correlate with any known naturally occurring mineral phases. Consequently, the cooling history and the paragenetic sequence can not be determined. The association of native bismuth plus hedleyite in veins implies a temperature of <266°C. The temperature history of the hydrothermal veins derived from zoning in silicate minerals (e. g. garnet, plagioclase) should be viewed with caution because this zoning is probably fluid-induced (i. e. metasomatic) and does not record the temperature of vein formation.

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The Mouton Shear Zone: Intersection of a Crustal-scale Fracture with a Crystallizing Granitoid Pluton

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The peraluminous tonalite-granodiorite-monzogranite Port Mouton Pluton (PMP) is a petrological, geochemical, structural, and geochronological anomaly among the many Late Devonian (373±1 Ma) granitoid intrusions of the Meguma Zone of southern Nova Scotia. We examine a possible genetic connection among several previously

unrelated textural and structural features in the PMP: well-developed linear compositionally banded monzogranites, chaotic schlieren-banded granodiorites, foliated monzogranites, mafic-felsic magma mingling, a swarm of aligned angular xenoliths, a breccia pipe, and abundant pegmatites. The most remarkable structural feature of the PMP is a wide (up to 2 km) zone of strongly foliated (040/subvertical) monzogranites culminating in a central, narrow (10-30 m), straight, centimetre- to decimetre-scale, compositionally banded zone that extends for at least 3 km along strike. These banded monzogranites have parallel-aligned feldspar and biotite crystals oriented during low-melt-fraction magmatic flow. They also show strong modal variations in mica and feldspar between bands, indicating efficient mineral-melt and mineral-mineral sorting. Internal deformation of feldspars, microcline twinning, blocky sub-grains in quartz, and kinking of micas indicate overprinting by a high-temperature grain-supported deformation. This major structural feature is approximately co-linear with the only four outcrops of Late Devonian mafic intrusions (376±2 Ma) in the area. Two of these mafic intrusions are synplutonic with well-developed mingling textures in the marginal tonalite of the PMP. Also closely co-linear with the mafic intrusions are a granitoid dyke that extends well beyond the outer contract of the PMP, a swarm of large aligned angular xenoliths, a zone of contorted schlieren banding, a large Be-bearing pegmatite, and a breccia pipe with abundant garnetiferous metapelitic xenoliths. We believe that the fracture that delivered the mafic magma and the breccia pipe to the upper crust also intersected the partially crystalline PMP. This syn-plutonic shearing resulted in turbulent stirring of the felsic magmas to produce the chaotic schlieren in the most liquid parts of the pluton, mafic-felsic magma mingling textures and deformation and segregation to form the zone of foliated and banded granitoids in the nearly crystalline part of the pluton, and brittle fracturing of the roof to release the angular xenolith swarm from the solid carapace of the pluton. The breccia pipe and pegmatites may be related to cataclasis and fluid flow in the fracture, respectively. This structural feature, here termed the Mouton Shear Zone, is parallel to the postulated post-intrusive Tobeatic Fault, and to two much younger Triassic-Jurassic features, the Shelburne Dyke and the Fundy Rift. These four lineaments may be old planes of weakness developed during docking of the Meguma Zone against North America.

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Re-interpretation of the Geology of the Cape Breton Highlands Using Combined Remote Sensing and Geological Databases

Funded by Acadia University and a research grant to S. M. Barr from the Natural Sciences and Engineering Research Council of Canada

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The Cape Breton Highlands are underlain by rocks which range in age from more than 1200 Ma to less than 360 Ma, and which display a wide range in composition. Relationships among these varied rocks, as revealed by geological mapping, are not everywhere clear, in part due to limited exposure and also to difficulty of access in some areas. This study was undertaken to try to improve on the geological interpretation of the highlands, especially in problematic areas, by combining geological and remote sensing databases.

In Nova Scotia, we are fortunate to have a wide variety of digital geological and geophysical information. For example, a large geological database exists for the Cape Breton Highlands based on detailed mapping, much of it at 1:10 000 scale, during the 1980s by faculty and students at Acadia University and, in the western highlands, Dalhousie University. More recently, additional mapping was done in some areas by geologists of the Nova Scotia Department of Natural Resources. For the present study, three different published digital geological map interpretations were used and compared.

Remotely sensed information used in the study included Radarsat S7, Landsat TM, gravity, magnetic (vertical gradient and total field) and radiometric data. A digital elevation model (DEM) was constructed from 174 Nova Scotia 1:10 000 scale contour map sheets. The geological, geophysical, and remotely sensed data were integrated into a Geographical Information System, and the resulting database was used to evaluate the various geological interpretations of the highlands. The ability to combine data sets and simultaneously interpret the spatial relationships among various sources of information on a quantitative basis allowed for more comprehensive input in the geology. The unsupervised classification of the radiometric data (K, eU, eTh, eU/eTh, eU/K, eTh/K) and the integrating of different image data sets together proved to be very useful in the interpretation process, especially with the detail of the elevation model that was constructed as part of the project. Although all the information collected was useful, it was the combination of all the data together that resulted in the enhanced interpretations. This aspect is where the role of the GIS is essential in collecting and storing data and, most importantly, in spatially analyzing relationships among the collected data sets.

The key results of the study are improved geological interpretations, in particular with respect to geological contacts between known maps units in poorly exposed areas, and in the location of major faults and postulated terrane boundaries. Granitoid map units were best detected and distinguished with the radiometric data. For example, the extent of the Bothan Brook granite was modified and field checked, and as a result, the Gold River deposit is now clearly in the contact metamorphic aureole of the granite. The vertical gradient fused with the elevation model and the gravity fused with vertical gradient provided particular insight into metamorphic and structural domains within the Cape Breton Highlands. These images clearly show, for example, that the Eastern Highlands Shear Zone is truncated by a major northerly trending structure that appears to merge to the north with the northeasterly trending Aspy Fault.

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From Faribault to Digital Mapping: Accessing GIS Databases at DNR

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The Digital Information Services group is responsible for developing and maintaining the Mineral Resources Branch (MRB) Geographic Information System and associated databases, the NovaScan bibliographic geoscience database, for supplying digital data and services to clients and staff, and for developing the MRB Internet web site. Staff consists of geologists Brian Fisher and Jeff Poole, and webmaster Susan Saunders.

The branch's digital product list currently stands at 32 maps, 6 databases and 5 geophysical image products. Three new products have been added this year:

- D00-01. Geological Map of the Province of Nova Scotia, Version 1, 2000, compiled by J. D. Keppie, 2000, scale 1:500 000.
  FREE DOWNLOAD
- DP 011. Enhanced Aeromagnetic and Digital Elevation Image of Eastern Nova Scotia, Version 1, 2000, M. S. King, (25 m x 25 m, 40 m x 40 m, 80 m x 80 m resolutions)
  FREE DOWNLOAD
- DP 012. Claim, mining tract and petroleum reservation grids for claim reference maps, Nova Scotia, Version 1, 2000. (distributed by 1:50 000 NTS map sheet)
  FREE DOWNLOAD

Four other products were also released as updated versions:

- DP 003. Drillholes database, Version 2, 2000
  FREE DOWNLOAD
- DP 010. Abandoned mine openings database, Version 2, 2000
  FREE DOWNLOAD
- DP 009. Claim reference map grid, Nova Scotia, Version 2, 2000
  FREE DOWNLOAD
- DC 001. Complete set of Nova Scotia Department of Natural Resources Digital Geoscience Data, Version 3, 2000 (CD product available through the Library)

Current projects include integrating the Registry of Mineral and Petroleum Titles database into the GIS and automating production of the ***Mineral Claims Disposition Map***. A number of products will be generated when this work is complete. Work continues on converting the NovaScan database so that it can be used in the GIS and future web-based applications. Work is also continuing on digitizing 45 geology maps and 30 detailed Faribault gold district maps into the GIS. All of these products will be made accessible in the Public Access GIS, and also as digital products available by free download through the branch web site. The department is also part of a cooperative project that built the 1:10 000 Digital Elevation Model (DEM) for the Province of Nova Scotia. DEM images will be added to the Public Access GIS in the future. The DEM will be available for purchase through the Nova Scotia Geomatics Centre.

The NovaScan database has now been added to the Provincial Library's government libraries catalogue database, and can be accessed and searched on-line over the Internet. To access the database, go to http://ncompass.library.ns.ca/DNR/ to take you into the ***NcompasS Database***, the name given to the Provincial Library consolidated catalogue database. Follow the search instructions from this point on.

Methods of data distribution have evolved over the past few years. Clients can still purchase digital products on disks or CDs through the library. However, we have now made all our digital data sets available for free download via the Internet from the MRB web site at http://www.gov.ns.ca/natr/meb/pubs/pubs3.htm. This initiative has resulted in over 5000 downloads in the first year of operation, as anyone with an Internet connection anywhere in Canada or the world can download the branch's data products.

Plans for the future are to create web-based Internet mapping applications which will allow clients to not only have access to data, but to also give them the tools to use the data to create custom maps. Internet Map Server technology is being used to build a number of prototype applications that are currently running in-house. These applications will be the "seed" for future client applications.

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Brines in the Sydney Coalfield: Remnants of the Windsor Sea

Funding from an NSERC Strategic Grant. Sincere thanks to many colleagues involved in the Carboniferous Hydrogeological Project, and to CBDC for access to their databases.

by ***M. R. Gibling***, Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 3J5

During its working life, the subsea Phalen Colliery near New Waterford periodically experienced inflows of saline water at the working face. There were fears that the ocean was breaking in, although some flows encountered were much more concentrated than seawater and nearly 700 m below sea level. Scientists from Dalhousie University, GSC

Atlantic, Cape Breton Development Corporation, ADI Nolan Davis and the Nova Scotia Department of Natural Resources investigated the inflows.

Analysis of water samples collected from sandstone tunnel roofs prior to mining shows that the saline waters are formational brines - part of the natural groundwater system of the deep rock column. They were flushed down into the Phalen Colliery during inflows from the overlying, drowned Lingan Colliery. The waters contain up to 176 000 mg/L of solutes (five times that of sea water), and are Na-Ca-Cl brines unusually enriched in Br relative to Cl. This suggests that the brine solutes originated by extreme evaporation of marine water, with Br remaining in the fluid after halite (chloride) precipitation. By comparison with a seawater evaporation curve derived from modern salt pans, the brines are enriched in Ca and Sr, but depleted in Na, K, Mg and SO_4- consistent with fluid-rock interaction in the rock column. The brines contain up to 1160 mg/L of Ba but have low metal contents (<0.1 mg/L Pb, <2.65 mg/L Zn).

We suggest that these residual brines originated during precipitation of thick Windsor Group evaporites (including halite) which locally underlie the Upper Carboniferous coal measures in the Sydney Basin. The dense brines would have recharged porous sediments adjacent to the evaporite basin, and probably entered the overlying coal-measure sandstones along faults. It may have been at this time that the brines mixed with other fluids: they plot close to the meteoric line on hydrogen/oxygen isotopic diagrams but distant from modern meteoric or ocean water.

The brines probably entered the sandstones during deepest burial of the coal measures, probably in the Permian or earliest Mesozoic. Evidence for this is that the brine-bearing sandstones are tight (average 6% porosity and 0.2 md permeability) and have been modified little since undergoing deep-burial diagenesis. Brine concentration patterns in the sandstones are highly irregular, suggesting that the brines are virtually immobile. Natural gas, generated from deep-burial maturation of the coals, presently occupies some pores.

In the shallower Prince Colliery, similar brines become progressively more concentrated with depth in the workings. They appear to have been diluted by surficial fluids that, based on isotopic data, were warmer than present precipitation, suggesting interglacial or preglacial sources. Prince sandstones are relatively porous (ave. 15%) and permeable (ave. 9.8 md), and we suggest that these surficial fluids increased the porosity locally by aggressively dissolving calcite cement. There is no sign in the coalfield that corrosive fluids from maturing coal have opened up significant pore space.

Saline fluid inclusions are common in Zn-Pb-Ba ore deposits (some as old as the mid-Carboniferous) in Atlantic Canada. We speculate that the Sydney Coalfield brines were formerly metal rich, as tiny crystals of sphalerite, galena and barite are present in ankerite and diagenetically altered feldspars in the sandstone. Basinal brines similar to those documented here were probably responsible for some phases of metal transport and emplacement within the region. Similar brines in sedimentary basins in Atlantic Canada are likely to influence well-log signatures obtained during hydrocarbon exploration.

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Stratigraphy, Structure, and Mafic Sills in a Section through the Halifax Group, Black River Area, Kings County, Nova Scotia

Funded by Acadia University and a Natural Sciences and Engineering Research Council of Canada Research Grant to S. M. Barr

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Field mapping was carried out in an essentially complete section through the Cambrian-Ordovician Halifax Group in the Black River area to investigate stratigraphy and structure compared to other areas, and the petrochemistry of associated mafic sills. The section examined is 3.5 km long and oriented NW-SE, approximately perpendicular to regional structural trends. It includes approximately 1 km of continuous outcrop in a recently constructed canal adjacent to Black River. The canal, part of the Black River hydroelectric system, has vertical walls ca. 5-10 m in height, and was mapped from a canoe.

The Halifax Group in the section is bounded on the southeast by metawacke of the underlying Goldenville Group, and on the northwest by quartzite of the overlying White Rock Group. Two lithologic units were recognized in the Halifax Group, based on differences in sand/silt/mud ratios, overall appearance, bed thickness, and nature of layering. The contact between the two units appears to be conformable and gradational. The lower unit consists of parallel laminated interlayered dark grey silty slate and light grey metasiltstone, and minor beds of massive, impure quartzite (metawacke), 0.5 to 2 m thick. Abundant sedimentary structures, including ripples and graded bedding, consistently indicate younging to the north. The upper unit is compositionally similar to the lower unit but differs in appearance. It consists of dark grey silty slate with light grey and locally light brown metasiltstone lenses. Only two quartzite beds, both less than 20 cm thick, were observed, and sedimentary structures are poorly developed. Quartz and quartz-carbonate veins and lenses are abundant in both units, and mainly occur in proximity to mafic sills.

Throughout the section, cleavage dips steeply to the south (mean of 55 measurements = 83°), and bedding dips steeply to the north (mean of 57 measurements = 78°), consistent with the presence of an unfolded stratigraphic section. No minor folds were observed. Minor strike-slip and oblique-slip faults cut the section, but lack of brecciation or apparent repetition of rare marker units suggests limited movement. A disjunctive shear foliation observed in both hand specimen and thin section is interpreted to represent Carboniferous re-activation of folds in the Meguma Supergroup, as has been reported elsewhere in the Meguma Terrane.

The section contains at least 15 metamorphosed and moderately to highly altered mafic sills that vary in width from less than 1 m to 6 m, although one sill exposed in Black River is 65 m wide. Like their host rocks, the sills show evidence for greenschist facies metamorphism, as indicated by the mineral assemblage chlorite, actinolite, epidote and albitic plagioclase. Interpretation of geochemical data from the sills, emphasizing least mobile elements, indicates that they are alkalic and formed in a within-plate tectonic setting. They have compositions similar to those reported from the older "type 1" sills in the Meguma Supergroup reported elsewhere in western Nova Scotia and interpreted to be penecontemporaneous with the Halifax Group. However, they are also chemically similar to volcanic rocks of the Silurian New Canaan Formation. Hence their age and tectonic implications remain uncertain.

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Mercury in Till and Soil Gas, Kejimkujik National Park, Nova Scotia

by ***T. A. Goodwin***, goodwita@gov.ns.ca, ***R. J. Nickel***, Department of Geology, Acadia University, Wolfville, Nova Scotia, B0P 1X0, and ***K. D. Page***, Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 4J1

The presence of elevated mercury levels has recently been identified in biota, most notably loons, in Kejimkujik National Park. The source of the mercury is currently unknown and is the focus of a multi-disciplinary research effort involving biologists, chemists, meteorologist and geologists. One geological and geochemical component of the research involves three steps: (1) collection and analysis of C-horizon till samples for mercury and multi-element geochemistry, (2) determination of mercury levels in till gas, and (3) determination of mercury concentrations in soil gas.

Approximately 60 till sites were sampled during the summer of 2000, most of these within the park. However, in

order to assess a geological source proximal to the park, additional samples were collected east and south of the park boundary. Sample sites were selected to adequately represent the various bedrock and surficial units identified on existing maps.

Till samples for geochemical analysis were collected at 500 m intervals along major roads and bush trails. The sampling process involved collection of a 5 kg and a 500 g C-horizon till sample from depths ranging between 1 m and 2 m. Pebble identification and preparation of heavy mineral concentrates will be conducted on all geochemically anomalous Hg samples.

Strict quality control protocols are being followed for the collection, preparation and analysis of the till samples. For example, each field site was photographed and detailed notes were recorded. For samples submitted for geochemical analysis, sample batches were routinely accompanied by a certified reference standard and a preparation split.

All samples will be analyzed for Au, Hg and multi-element geochemistry. Future processing of the 5 kg bulk till samples may include preparation of heavy mineral concentrates, mineralogical descriptions and pebble identification. All sample material is currently being stored at the department's core library in Stellarton.

At approximately 50% of the till sites, real-time mercury in soil gas was measured using a Dräger accuro Gas Detection Pump fitted with mercury detection tubes. All readings were less than the lower detection limit of 0.05 mg mercury/m^3. Additional sites from immediately outside the park boundary are currently being assessed using Quicksilver Systems' mercury detectors, which are buried for 30 days at a depth of approximately 30 cm. Metal strips attached to the detectors are subsequently analyzed for their adsorbed mercury content. Results are pending.

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The Terrestrial Impact Record

by ***R. A. F. Grieve***, Director General (Acting), Sedimentary and Marine Geoscience Branch, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

Planetary exploration has shown that impact is a ubiquitous geologic process in the solar system and was a dominant process in early planetary evolution. The Earth, however, is the most endogenically active of the terrestrial planets and, thus, has retained the poorest sample of impacts that have occurred throughout geological time. The current known terrestrial sample consists of approximately 160 impact structures or crater fields. There are also some 20 impact events registered as depositional events in the stratigraphic record, some of which are related to known structures. The sample is biased towards young (<200 Ma), large (>20 km diameter) impact structures on the geologically better known cratonic areas. Approximately 30% of known impact structures are buried and were initially detected as geophysical anomalies and subsequently drilled to provide geologic samples.

Terrestrial impact structures provide important data for understanding impact processes, as they are the only source of ground-truth data on the lithological and structural nature of impact craters in the third dimension. In the geologically active terrestrial environment, anomalous quasi-circular topographic, geologic and/or geophysical features, however, do not automatically equate with an impact origin. Specific samples must be acquired and the occurrence of shock metamorphism, or, in the case of small craters, meteoritic fragments, must be demonstrated before an impact origin can be confirmed. Terrestrial impact structures result in unusual local geologic conditions, which can lead to the concentration of natural resources, such as minerals and hydrocarbons; in some cases, the economic deposits are world-class, such as Sudbury, Vredefort and the Campeche Bank oilfield. Impacts are highly transient, extremely high-energy events that can effect Earth systems. For example, a major impact on the proto-Earth is currently the best working hypothesis for the origin of the Earth's moon. In more recent geologic time, the Chicxulub impact structure in Mexico was most likely responsible for the global mass extinction of the biosphere at the Cretaceous-Tertiary boundary, 65 million years ago. Such events occur on time scales of hundreds of millions of years. More frequent and smaller events occurring on the scale of less than a million years represent a long-term threat to human civilization.

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Eastern Shore Compilation Project

by *L. J. Ham* and *P. K. Smith*, pksmith@gov.ns.ca

A wealth of information exists in the Nova Scotia Department of Natural Resources (NSDNR) databases, private research files, and in internal company reports on the numerous gold districts and base metal occurrences located along the Eastern Shore of Nova Scotia. Geological maps were produced early in the 19th century by E. R. Faribault, and there was subsequent work by Malcolm in 1929. Since that time, there has been considerable work undertaken by various mineral exploration companies, prospectors, universities and other parties.

As a result, the Eastern Shore Compilation Project was initiated to: (1) compile all pre-existing information on the gold districts and surrounding areas of the Eastern Shore, (2) incorporate all relevant information on a digital base with attached databases, and (3) write site-specific deposit reports.

Work thus far on the project has involved deposits on NTS map areas 11F/03, 04, 05 and 06. Field visits were undertaken to the gold districts of Country Harbour, Upper and Lower Seal Harbour, Isaac's Harbour, Wine Harbour (11F/04), Forest Hill and Mile Lake (11F/05) and the tungsten showing at Lazy Head (11F/06). In addition, numerous smaller showings and occurrences of various commodities were visited. To date, no significant mineral showings are reported for NTS map sheet 11F/03.

Work in 2000 has involved primarily digitizing the early work of Faribault and correcting and referencing the work onto digital bases. This work was done in AutoCAD® 14 with Fieldlog® 3.4 for the database component. This work will then be incorporated in ArcView® 3.1 with other work compiled last year (mineral occurrences and drillholes, both from NSDNR databases and Geological Survey of Canada geological maps) and other information currently in digital form (i.e. geophysics). Other geological information, including cross-sections and mine plans, will be incorporated in the digital base maps and databases in the near future.

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Overview of the Southwest Nova Mapping Program 1998-2000

by *R. J. Horne*, rjhorne@gov.ns.ca and *C. E. White*, whitece@gov.ns.ca

Mapping of lower to middle Paleozoic metamorphic rocks has been conducted during the last three years in the Digby-Weymouth-Yarmouth area. This work has resulted in significant revisions to previous maps, including subdivision or re-assignment of stratigraphy, re-interpretation of fold geometries, recognition of regional-scale shear zones, and identification of new mineral occurrences.

The oldest rocks in the map area belong to the Meguma Group, including the lower Goldenville Formation and conformably overlying Halifax Formation. The Goldenville Formation consists mainly of undivided metasandstone with variable amounts of interbedded metasiltstone and rare slate. The Halifax Formation has been subdivided into three members in the northern part of the map area. The Bloomfield member occurs at the base of the Halifax Formation and consists of a distinctive green to maroon metasiltstone. The Bloomfield member is conformably overlain by grey slate of the Acacia Brook member or black slate of the laterally correlative Cunard member. Upper units of the Halifax Formation include the Bear River member (Tremadocian), consisting of silty slate, and the laterally correlative Sissiboo member, consisting of thinly bedded, planar stratified, colour banded slate and

metasiltstone. Poor exposure inhibits subdivision of the Halifax Formation in the southern part of the map area. The Meguma Group is disconformably overlain by the White Rock Formation (Silurian), consisting of dark slate with minor metasiltstone, marly metasiltstone and quartzite in the northern part of the area. However, in the south this unit is characterized by strongly deformed amphibolite, garnet ± staurolite ± andalusite schist, quartzite and metasandstone. Contacts with the older Meguma Group are tectonic. The Torbrook Formation (Early Devonian) conformably overlies the White Rock Formation in the northern part of the area and consists of slate and locally fossiliferous metasiltstone.

Lower Paleozoic rocks were deformed into regional NE- to NNE-trending, moderately plunging folds during the Devonian Acadian Orogeny, with the younger Halifax, White Rock and Torbrook formations exposed in synclines. Regional deformation and metamorphism is complex and not yet resolved. In the northern part of the area regional metamorphism is greenschist facies. In this area, deformation in the White Rock Formation and, especially, the Torbrook Formation is significantly less intense than in the Meguma Group, possibly reflecting initiation of deformation prior to their deposition. In the southern part of the area the White Rock Formation is strongly deformed and records amphibolite facies metamorphism, whereas the adjacent Meguma Group records greenschist facies metamorphism. Metamorphic boundaries are typically abrupt and defined by shear zones.

Post-Acadian deformation is widespread, with shear zones commonly developed at the boundary of the Goldenville and Halifax formations, which record dip-slip and strike-slip displacements. Stratigraphic succession is generally maintained across shear zones; however, regional scale truncation of Goldenville stratigraphy occurs in the Richfield area, where the White Rock Formation is in contact with the Goldenville Formation. A NE-SW mylonitic shear zone, the Kemptville shear zone, is developed in the Goldenville Formation from Carlton to East Kemptville and also appears to be truncated by the above shear zone. The shear zone is steeply dipping and records a dip-slip, SE-side-up shear sense. Several brittle faults occur in the area.

Several new mineral occurrences have been identified, most notably Cu-Mo associated with quartz veins cutting the Clayton Hill pluton and Cu-Sn-Ag-Zn-bearing skarn (calc-silicate) in Goldenville Formation rocks in the Weymouth area. Several gold occurrences lie within the Kemptville shear zone, presenting a good target for further evaluation. Faulting along Napier River is characterized by brecciation, silification and epithermal textures, similar to mineralized faults south of the area.

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The Paleoplacer Potential of the St. Marys Basin

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The St. Marys Basin of mainland Nova Scotia, Canada, consists of Late Devonian-Early Carboniferous clastic rocks of the Horton Group deposited in the waning stages of the ca. 420-360 Ma Acadian Orogeny in the Canadian Appalachians. Clast lithologies and lithogeochemical analyses indicate that the detritus was predominantly derived from the Meguma Terrane, which occurs to the south of the basin. The Meguma Terrane contains abundant mesothermal gold deposits that are coeval with peak magmatic activity from ca. 380 to 370 Ma and underwent rapid uplift and erosion between ca. 370 and 360 Ma.

Within the St. Marys Basin, the contact between the lacustrine Little Stewiacke River Formation and the fluviatile Barrens Hills Formation is interpreted to represent a shoreline and a potentially favourable environment for depositing paleoplacer gold. Geochemical analyses of lithologies adjacent to this contact indicate that the siltstones are predominantly derived from Meguma Terrane metasedimentary rocks, whereas the sandstones and conglomerates are predominantly derived from Meguma Terrane granitoids. Geochemical and mineralogical analysis indicate the accumulation of heavy minerals including zircon and gold. Micron-scale (<150 μm) gold identified in the matrix of the conglomerates has a "nuggety" appearance and flaky microtexture indicative of a detrital origin. This observation

indicates that the mesothermal deposits were exhumed by the latest Devonian, consistent with regional tectonic syntheses that invoke rapid uplift of the Meguma Terrane following peak orogenic activity. This study suggests that favourable depositional environments for paleoplacer deposits may occur in Horton Group rocks that are derived from the Meguma Terrane.

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Mineral Deposit Studies in Nova Scotia: I. Industrial Minerals

by ***D. J. Kontak***, kontakdj@gov.ns.ca

Mineral deposit studies focused on a variety of industrial minerals during the past year. The projects primarily address the following objectives: (1) improve our understanding of the environment of mineralization, which in many cases depends on how recent the mineralized sites have been worked or mined, and (2) develop conceptual models applicable to the immediate mineralized area or for exploration of similar mineralization within outlying areas. Work done in mineralized areas initially involves field studies to map out the zone of interest and to determine macro-scale features that control its distribution (e.g. alteration, structures). Follow-up laboratory studies are done on well characterized samples collected from the mineralized sites to determine other important factors that have controlled mineralization. The following summarizes some of the work completed at these sites.

Brookfield barite: Coarse, crystalline barite occurs within a structurally complex stratigraphy of Carboniferous rocks dominated by buff sandstones and red siltstones. Barite and associated siderite occurrences are structurally controlled adjacent to an E-W fault system and intimately associated with intense wall-rock alteration (i.e. green discoloration of redbeds) and distal Fe-Mn mineralization. Laboratory studies indicate that sulphur (Delta^{34} S = 11-15) originated from Windsor Group evaporites (Delta^{34} S = 11-15) and that the mineralizing fluids were highly saline (24 wt.% equiv. NaCl) and of moderate temperature (200°C), thus similar to basinal brines. Interestingly, the barite is inundated with low density CH_4 inclusions which infers mineralization occurred at P≤100 bar (i.e. ca. 300 m). The presence of an alteration halo about the mineralized zone provides an excellent exploration target.

Annapolis Valley zeolites: The Jurassic North Mountain Basalts along the Annapolis Basin are world famous for their abundant zeolites, occurring as amygdules and also replacing matrix feldspar and glass. The amygdaloidal zeolites, of hydrothermal origin, fill primary porosity generated via degassing of the basaltic magmas during and after eruption. Detailed study of the distribution of the amygdules indicates a zonation from the bottom (e.g. pipe vesicles) to the top (vesicle pipes) of flows, which may be used to guide exploration and development. Important aspects relating to the zeolite mineralization which are under study include: (1) the heterogenous distribution of amygdaloidal flows, (2) the complicated architecture of flows, (3) the distribution of the various zeolites, and (4) the nature and origin of the fluids responsible for zeolite formation.

Peggys Cove pegmatites: The South Mountain Batholith locally contains tourmaline pegmatites. What are the conditions favoring the formation of such pegmatites and is there potential for gem-quality tourmaline in the pegmatites? In order to address these questions, a study of the well-exposed pegmatites in the Peggys Cove-West Dover area was initiated. The pegmatites occur within a primitive biotite monzogranite and form as layered aplite-pegmatite sheets with classic internal fabrics and layering. Tourmaline, occurring as part of quartz-tourmaline core zones, is usually massive and crystalline but no coarse, isolated crystals have yet been found. Tourmaline-rich zones are laterally discontinuous and no more than 1 m wide. Geochemically (e.g. Rb contents of K-feldspar) the pegmatites are not extremely fractionated; hence, they do not appear to represent end products of an evolved felsic magma and, instead, a local contamination model of formation is preferred.

Flintstone Rock quartz-clay: Quartz and clay replace granite in a ca. 200 m wide fault zone on the southern margin

of the 370 Ma Davis Lake pluton. The mineralized zone is related to infiltration of low salinity (<1 wt. % equiv. NaCl) fluids of ca. 250-300°C. These fluids may represent late circulation of waters related to the cooling of the pluton. The presence of regional-scale fault structures throughout the area offers promise for occurrence of further mineralization.

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Mineral Deposit Studies in Nova Scotia: II Base Metals and Precious Metals

by ***D. J. Kontak***, kontakdj@gov.ns.ca

Mineral deposit studies, focusing on a variety of base metal and precious metal environments, continued in a variety of settings in 2000. The projects listed below were initiated to address some specific objectives: (1) improve our understanding of the environment of mineralization, which in many cases depends on how recent the mineralized sites have been worked or mined, and (2) develop conceptual models for exploring around mineralized areas or for exploration of similar mineralization within outlying areas. In some cases the development of conceptual models may have evolved dramatically since the last time some mineralized sites were studied (e.g. Stirling mine) and this may have an impact on how such areas are now explored.

Efforts over the past few years have focused on both mineralized areas (e.g. Stirling and Coxheath deposits) and also processes (e.g. crack-seal texture in Meguma gold deposits) and some of the results are highlighted below. In all cases, work initially involves field studies to map out mineraled zones and determine macro-scale features that control their distribution (e.g. alteration, structures). Follow-up laboratory studies are done on well characterized samples collected from the mineralized sites to determine important factors which have controlled the mineralization.

Stirling massive sulphide deposit: Production of ca. 1 Mt of Zn-Pb-Cu-Ag-Au sulphide ore came from Zn-rich sulphides hosted by 680 Ma intermediate volcaniclastics deposited within a submarine, continental arc environment. Host rocks are cut by a high-level quartz-feldspar porphyry, which is considered to have driven the hydrothermal cell responsible for mineralization. The host volcaniclastics are pervasively altered to a quartz-talc-carbonate (QTC) rock and everywhere mineralization is hosted by this rock. The QTC alteration extends below the ore horizon, but not above it, and is considered to represent a travertine-like deposit formed during the waning stages of hydrothermal activity. Intense deformation of the ore zone resulted in boudinaging of the mineraled zone, which accounts for the lens shape of sulphide bodies. The anomalous Delta^{34}S levels (plus 15-19‰) for sulphides suggest anoxia prevailed, similar to the large Bathurst deposits of New Brunswick, which is consistent with the presence of fine-grained, laminated dark siltstones and shales overlying the deposit and regionally extensive black shales in the Stirling Group.

Coxheath porphyry Cu-Mo-Au: Aerially extensive Cu-Mo-Au enrichment occurs in veins and disseminated in a suite of 620 Ma calc-alkaline plutonic-volcanic rocks. The unmineralized host rocks are hornblende diorite and basaltic andesite with continental island arc chemistry. Mineralization occurs predominantly as massive to sheeted, subvertical vein swarms within a diorite with associated potassic and boron alteration. Breccias typical of porphyry deposits are rare. The deposit is considered to represent a deep-seated, porphyry style of mineralization.

Crack-seal textures in Meguma gold veins: Many of the auriferous veins in the Meguma Group are characterized by ribbon or crack-seal textures; therefore, it is relevant to asses the origin of this texture. Detailed studies of crack-seal textures from many deposits suggest that they relate in part to disaggregation, recrystallization and alteration of wall-rock inclusions in contrast to the conventional ideas for this texture (i.e. crack and seal formation). The implications of this work relate to gold paragenesis, which currently suggests that gold occurs in the white crystalline quartz that is younger than most crack-seal textured quartz. Thus, the presence or absence of crack-seal textured quartz does not influence the potential for gold.

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Registry of Mineral and Petroleum Titles

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The Registry of Mineral and Petroleum Titles is responsible for receiving applications for mineral and petroleum rights, and for issuing and registering licences and leases. In addition, documents affecting licences are registered by this office. The registry also receives statements of exploration expenditures and assessment reports that pertain to the renewal of licences and leases. Maps showing the disposition of lands under licence or lease are maintained and continually updated. The registry also maintains a system of Prospector Registration, including the issuance of prospector's identification cards. Applications for underground gas storage rights and treasure trove rights are also processed though this office. Information concerning production and employment in Nova Scotia's mines and quarries is received and compiled by the registry and published annually.

Staking Activity

The total area under exploration licence, including special licence, at the end of 1999 was approximately 230 660 hectares, up roughly 50% over 1998's figure of 151 000 hectares. Staking levels for the first eight months of 2000 show a downward trend, with approximately 198 000 hectares under licence at the end of August. Interest in Nova Scotia's underground gas storage potential continues, however. On July 27, 2000, an additional 37.6 km^2 were designated as a gas storage exploration area. Preliminary figures indicate exploration expenditures (field plus overhead) totaled $3.4 million in 1999, down moderately from the year before. If engineering, economic and feasibility studies as well as environmental and land access costs are added, the total is $4.2 million. The majority of these expenditures were made by junior mining companies searching for industrial mineral commodities (kaolin, silica, titanium, barite). Expenditures for 2000 are forecast to be similar to 1999.

Mining Activity

In 1999, the estimated value of Nova Scotia's mineral production, including secondary mineral processing but excluding crude petroleum, totaled $340 million, a 3% decrease from the year before. Coal sales dropped by 25% as production problems continued to plague the province's largest coal mine, the Cape Breton Development Corporation's Phalen Colliery. On September 13, 1999, after yet another roof-fall, the federal Crown Corporation announced it was closing Phalen. The colliery produced just under 17 million tonnes of coal over its fifteen year life. The province's only gold mine, Tangier Limited Partnership's Blueberry Hill Mine in Tangier, Halifax County, closed after only a few months of operation, citing poor recoveries.

On a positive note, 1999 was a record year for Nova Scotia gypsum production with 7.9 million tonnes shipped, mainly to wallboard plants along the US Eastern Seaboard. Nova Scotia is Canada's largest gypsum producer, accounting for more than 80% of the country's total production. Shipments of cement, barite and clay products also increased in 1999 while salt production remained virtually unchanged at 842 000 tonnes. Production of construction aggregates (crushed stone, sand and gravel) in 1999 totalled 10.6 million tonnes, down slightly form the year before. Employment in Nova Scotia's mineral industry totalled roughly 2500 persons, a decline of 24 % from 1998 levels. This was primarily due to the closure of the Phalen Colliery.

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Mineral Exploration Monitoring

by ***P. D. McCulloch***, mccullpd@gov.ns.ca

The level of mineral exploration in Nova Scotia during the first nine months of 2000 has continued at approximately the same level of activity as in the previous three years. In general, the level of exploration expenditures has continued to decline over the past three years, with field expenditures expected in the range of $3-4 million for 2000, compared with $3.8 million for 1999 and $5.6 million in 1998. Exploration focused primarily on industrial minerals, and to a lesser extent on base metals and gold. In this regard, interest in the exploration and development of industrial mineral commodities has strengthened in recent years, whereas activities related to the exploration and development of base metals and gold have been on the decline due primarily to low commodity prices for metals and the difficulty in raising venture capital to fund exploration programs. Highlights of exploration activities during the first nine months of 2000 are outlined below.

Exploration and development of industrial minerals continued in 2000, with specific interest in kaolin, silica sand, limestone and zeolites. Kaoclay Resources Incorporated continued a detailed evaluation of Cretaceous kaolin and silica sand deposits in the Musquodoboit and Shubenacadie valleys of central mainland Nova Scotia. The company completed extensive diamond-drilling on the Sibley Road prospect in the Middle Musquodoboit area late in 1999 and has recently been conducting detailed analytical studies at Kaoclay's pilot plant in Georgia.

Black Bull Resources Incorporated, under an option agreement with CAG Enterprises Limited, continued a detailed exploration program for kaolin and silica in an altered quartz-kaolinite breccia zone along the Tobeatic Shear Zone in the Flintstone Rock area, Yarmouth County. The company recently completed trenching and preliminary bulk sample testing and plans to complete additional diamond-drilling and large-scale bulk sampling during the fall.

C_2C Mining Corporation continued a detailed evaluation of the zeolite potential of amygdaloidal basalts along North Mountain in western Nova Scotia. The company recently completed additional diamond-drilling on its Stronach Mountain property in Annapolis County. NAR Resources, under an option agreement with Titanium Corporation of Canada Limited, continued to evaluate the titanium potential of heavy mineral sands in the Shubenacadie River near Maitland, Hants County. The company recently completed additional heavy mineral sampling for metallurgical studies.

Statia Terminals Canada Limited continued a detailed evaluation of the potential for developing underground bulk hydrocarbon storage in the extensive salt deposits of the Windsor Group in the Port Richmond area near Port Hawkesbury. Recent work included a review of previous geological and geophysical work completed on the property.

Goliath Copper Fields Limited initiated a detailed evaluation of the base metal potential in the vicinity of known mineral occurrences in the College Grant, Lochaber Lake and Cross Roads Ohio areas along the southeastern boundary of the Antigonish Highlands. Additional work was also carried out on the company's West Lochaber property which is host to a low grade sedimentary copper deposit with reserves of 2.4 million tons grading 0.33% Cu. True Metallic Explorations Incorporated continued a detailed evaluation of the paleoplacer potential for gold associated with clastic sedimentary rocks of the Lower Carboniferous Horton Group near Castle Frederick, Hants County. The company recently completed geological mapping in the area and plans to conduct a drilling program on the property during the fall of 2000.

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The Drill Core Library

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The provincial Core Library, located in Stellarton, Pictou County, is operated as a program of the Geoscience Information Services Section of the Geological Services Division, DNR. The Core Library provides a range of services to the private sector, government and universities.

The principal function of the Core Library is to curate and preserve valuable geological sample material obtained as a

result of exploration, development and geological survey work carried out in Nova Scotia. Preservation of these materials contributes to the promotion of greater economic opportunities for Nova Scotians through future development and production of minerals and hydrocarbons. Clients include exploration company geologists (both mineral and energy sectors), DNR staff geologists, university researchers, prospectors, engineering firms, geotechnical consultants and Geological Survey of Canada geologists.

The primary sample material, derived from more than 7000 drilled holes, is 658 000 m of diamond-drill core, estimated to represent a replacement value of $54 million. This core has been obtained over a period of 40 years from the private mining and exploration sector as well as from geological survey programs of the Mineral Resources Branch and its forerunners. Drill core has been obtained from the search for coal, gypsum, limestone, aggregates, base metals, gold, salt, potash, celestite, tin, aggregates and kaolin, as well as from geological research. In addition to core, the Core Library is the official provincial repository for all sample material derived from onshore oil and gas exploration and development carried out under the jurisdiction of the Nova Scotia Petroleum Directorate. This consists primarily of drill-cuttings from about 90 000 m of drilling in onshore oil and gas wells, representing a drilling cost of about $70 million. The Core Library also serves as the repository for large quantities of geochemical, rock, till, soil, stream and lake sediment samples, and other samples obtained by DNR field geologists.

All this sample material provides a wealth of information that would otherwise be unavailable except at great expense. Clients may examine all sample material and may be permitted to take representative samples for further study and analysis provided that the resulting data are provided to the department.

One of the key information sources used by clients of the Mineral Resources Branch is maintained by staff at the Core Library. The department's Drillholes Database (which is continuously being updated) consists of more than 21,000 records of drilling carried out in Nova Scotia and is searchable by any combination of parameters. Access to technical reports, logs and other reference material can also be provided by Core Library staff.

Two geologists are on staff to provide clients with access to core, cuttings and other sample materials, together with related data and information files. Appointments are required to ensure the availability of staff, equipment and lab space. Clients are encouraged to call well in advance of a visit to the facilities to ensure their needs can be met. Core Library staff may be contacted by phone (902-752-4842), by FAX (902-777-7186) or by e-mail (mcmulljm@gov.ns.ca). Visit our web page at http://www.gov.ns.ca/natr/meb/one/dcl-home.htm.

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New 1:10 000 Scale Mapping of Carboniferous Strata Adjacent to the Cobequid Fault Zone

by ***R. D. Naylor***, rdnaylor@gov.ns.ca, ***C. H. Giles*** and ***C. M. Kennedy***

Upper Carboniferous strata of the Cumberland Group outcrop immediately south of the Cobequid Fault Zone in a narrow (7-15 km) belt that stretches approximately 180 km from Advocate Bay to Stellarton. The Nova Scotia Department of Natural Resources has recently completed 1:10 000 scale mapping of this succession in the Great Village to Kemptown area. The purpose of this work is to develop a more detailed stratigraphic and structural framework for the late Carboniferous to help support future mineral and energy exploration.

Previous mapping suggested that within the study area the Cumberland Group could only be found in stratigraphic contact with rocks of the Cobequid Massif. All other contacts between the Cumberland Group and other stratigraphic units were believed to be fault contacts. However, our mapping has identified some locations where the Cumberland Group can be found in stratigraphic contact with the mid-Carboniferous Mabou Group and the Triassic Fundy Group.

Rapid lateral facies changes characterize much of the Cumberland Group within the map area. Coupled with

widespread faulting this often makes stratigraphic correlation and mapping of formation boundaries challenging. Prior to the current mapping program the lower 2500 m of the Cumberland Group had been assigned to the Parrsboro Formation (late Namurian to early Westphalian A). The remainder of the Cumberland Group had been informally referred to as the Delany Formation (Westphalian A to D). Our work suggests that the Cumberland Group can actually be subdivided into at least seven formations within the map area. The Parrsboro Formation can be subdivided into the Lower Parrsboro Formation (sandstone dominated) and the Upper Parrsboro Formation (mudrock and organic-rich shale dominated). We are recommending that the informal use of the Delany Formation be abandoned and that strata previously included in this formation should be assigned to five new formations. These new formations in stratigraphic order are the North River, MacCullum Settlement, Folley River, Weatherby Brook and Tunnel Brook formations. The Folley River Formation is predominantly grey and coal-bearing. The MacCullum Settlement and Weatherby Brook formations are characterized by conglomerate facies. The Tunnel Brook and North River formations are composed of channel sandstones separated by red mudrocks.

The structural geology of the map area is characterized by major east-west faults that are locally cut by northwest-southeast faults. The Cobequid Fault, which forms the northern boundary of the map area, is locally exposed along rivers and streams and very well exposed along the recently constructed Cobequid Pass. Our work suggests that the Cobequid Fault locally bifurcates around large blocks late Carboniferous rock.

The maps created as part of this project will be released as Open File Maps early in 2001.

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Paleoweathering in Granitoids of Southern Nova Scotia: Implications for Metal Release into the Environment

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Saprolite, the intensely weathered, friable material developed ***in situ*** as a result of prolonged intense weathering of crystalline rock, is not what one expects to see in Nova Scotia, where extensive glaciation has occurred in the geologically recent past. However, granitoid saprolites formed prior to the Pleistocene glaciation can be found at several sites throughout the South Mountain Batholith of southwestern Nova Scotia, where they vary in thickness from less than 1 m to over 30 m.

Saprolites have drastically different physical and chemical properties than their unweathered parent and these differences contribute to a host of potential environmental considerations. Physical properties such as increased permeability and decreased yield strength may affect groundwater flow and building stability, respectively. Chemical changes during the weathering process can release major elements such as K and P, which in turn may contribute to the creation of fertile soils. Chemical changes during the weathering process can also release elements such as Mn, U or Hg into the surface environment, toxic elements which contribute to contamination of waters and soils, and ultimately to the health of animals and vegetation. The presence of saprolites preserved beneath glacial deposits in the South Mountain Batholith poses a number of additional questions: When did these weathered paleosurfaces form? Under what climatic conditions did they form? How are they preserved despite glaciation? Can we distinguish between different ages and types of saprolites on the basis of chemistry, mineralogy, and micromorphology?

The nature and environmental implications of these weathered paleosurfaces form the basis of an ongoing Ph. D. study by the first author. Preliminary work indicates that saprolites formed on the granitoids prior to the deposition of the Horton sediments, and again prior to deposition of the Triassic sediments. Field relationships suggest that there

may have been a third period of saprolite development sometime between the Triassic and the Pleistocene. Geochemical, mineralogical and micromorphological analyses will help define possible sources and pathways of toxic element mobility in the near-surface environment. In addition, this study will investigate the processes involved in the development and subsequent history of these saprolites, and develop a classification of the various saprolites in terms of age and chemical and physical makeup. These data will be used to consider possible paleoclimatic conditions responsible for the formation of these saprolitic profiles.

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Structural Orientations, Architecture and Timing of Auriferous Quartz Veins Associated with Mesothermal Saddle Reef Stockwork Gold Mineralization, The Ovens, Lunenburg County, Nova Scotia

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A 680 m long east-west cliff section of continuous exposure along the north shore of Rose Bay, The Ovens, Nova Scotia, was measured along a reference line to determine the locations, attitudes and timing relationships of conjugate, thrust-related and bedding-parallel (saddle reef) Au-quartz-sulphide veins. The section occurs along a tight east-west anticline in the Cunard Formation, Halifax Group, Meguma Supergroup. Over 5400 veins were observed ranging from less than 1 mm to 215 mm wide, and the relationships between the veins and associated structures within the sediments were documented. Longitudinal plots and statistical tests were performed to determine whether these veins are randomly or systematically located in space. Results indicate that the veins exhibit a non-random, approximately uniform distribution within structural domains, and that changes in the abundance and net dilation of the veins occur at structural domain boundaries.

Stratigraphic measurements of the host sedimentary rocks reveal a monotonous exposure of fine-grained turbidites at least 75 m thick. Cleavage within these rocks exhibits distinctive refraction at fine- to coarse-grained bed contacts, and within the coarser grained beds a fan cleavage morphology occurs. Geological mapping indicates that two types of thrust faults exist. The first consists of several associated thrust planes that verge north and rotated earlier-formed conjugate veins above them (as documented by changes in calculated principle stress orientations). The second thrust type is represented by many smaller back-thrusts, which are restricted to the south limb of the anticline and verge steeply south. These are most abundant near and along the axis of The Ovens anticline, and commonly host auriferous quartz (spur) veins in orientations sub-parallel to slightly shallower than the bedding-parallel veins along the north limb of the anticline.

Conjugate veins can be constrained to have formed during an extended period of folding and north vergent thrust faulting (involving significant rotation). East- and west-dipping conjugate veins appear to be synchronous; however, back thrusts and spur veins filling these back thrusts appear to have formed generally after these conjugate veins, based on cross-cutting relationships. By association, because the spur veins appear to be extensions of north-dipping saddle reef/bedding-parallel veins, the saddle reef/bedding-parallel veins are interpreted to post-date the earlier conjugate veins.

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Activities of the Mineral Inventory During the First

Half of 2000

by ***G. A. O'Reilly***, gaoreill@gov.ns.ca and ***G. J. DeMont***, gjdemont@gov.ns.ca

During the first half of 2000 the Mineral Inventory focused its efforts on several initiatives. An expressed interest by Granirex Inc. of Quebec in obtaining high purity, white "bull" quartz from Nova Scotia led us to carry out a compilation of known and potential occurrences of this industrial mineral commodity during the spring. In the past there has been exploration, and even small scale production, of quartz from thick quartz veins at several locales within the Meguma Group. However, this work was directed toward using the quartz as a source of silica sand for the production of specialized concrete products. The Granirex interest is for production of high quality synthetic polished slabs for use in the commercial and home building industries. Our compilation showed that there are several sites showing very high potential, including veins at the Little Liscomb Lake, Fifteen Mile Stream and Beaverdam gold districts; the Wire Lake and North Beaverbank silica prospects; and the past-producing Elderbank silica deposit.

Mineral Inventory field checking of mineral occurrences continued in the Eastern Shore region between Upper Musquodoboit, Halifax County, and Glenelg, Guysborough County, and commenced in the Antigonish Highlands in the Georgeville and Kirkmount areas. At present the Antigonish Highlands review is concentrating on fault-controlled Zn mineralization associated with the Hollow Fault system. At several sites significant intersections of low-grade zinc were found during past exploration. These indicate there was a widespread and pervasive mineralization episode in that region which warrants further exploration. The Eastern Shore effort included further examination of the beryl potential of pegmatites occurring in the Lower Caledonia area of Guysborough County. A pegmatite rich in beryl was discovered there during a Mineral Inventory field check of the Lower Caledonia gold prospect in 1999.

The federal government, under the Targeted Geoscience Initiative, initiated the Geological Mapping for Mineral Development in South-central Cape Breton Island Project. As part of department's commitment to this project, Mineral Inventory staff initiated compilation and field checking of industrial mineral occurrences in the project area. In addition, evaluation of the industrial mineral potential of reddish and white marble occurrences in the Kennedys Big Brook area near Marble Mountain continued. In that same area further stream sediment sampling was carried out in cooperation with department geochemist Terry Goodwin as a follow-up to discovery of several gold anomalies encountered there in a 1999 survey.

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Aggregate Program Activities

by ***G. A. Prime***, primega@gov.ns.ca

The current focus of the Aggregate Program is an evaluation of the aggregate resource in the Annapolis Valley region. Covering an area from Hants County to Yarmouth County, the study is examining the bedrock and surficial geology to determine aggregate potential. The research is primarily a resource mapping project supported by air photo interpretation and a limited sampling program. The outcome of the work will be a GIS digital database for aggregate resources throughout the region.

Activities for the 2000 field season will see the completion of field work in Hants, Kings and Annapolis Counties. At the time of writing, two months of field work are planned for September and October to examine sites which were not covered in previous years.

Findings of the study to date indicate that the quality of an aggregate source, whether bedrock or surficial, is primarily a function of rock durability and resistance to weathering. Rock types that typically produce sound aggregate in gravel include metamorphosed sandstone (commonly called quartzite), many of the granitic rocks, and some of the crystalline basement rocks from the Cobequid Highlands. Unsuitable rock types include unmetamorphosed

(Carboniferous or Triassic) sedimentary rock, the amygdaloidal basalt of the North Mountain, weathered or highly fractured granitic rocks from the South Mountain Batholith, and Halifax Formation slates. They usually produce soft or platy clasts which lack durability and are prone to weathering. In order for a gravel to produce good aggregate it must contain a very high percentage of durable clasts. Unfortunately, most of the gravel deposits in the study area contain enough low quality stone to reduce their aggregate potential. The abundance of these materials in the deposits probably reflects the preferential glacial erosion of weakened bedrock.

The requirements for good bedrock aggregate parallel the characteristics needed for high quality gravel. Characteristics such as rock hardness and resistance to weathering processes are high priorities. Rock types which generally exhibit these characteristics include metamorphosed sandstone, fine- to medium-grained intrusive rocks, and some massive basalts. Many of the competent, coarse-grained intrusive rocks have also been successfully used as high quality aggregate. Rock types which generally lack the durability for construction aggregate include the Carboniferous and Triassic sedimentary rocks, Halifax Formation slates, amygdaloidal basalts, and highly microfractured granites.

It should also be emphasized that successfully locating a high quality bedrock aggregate deposit involves more than identifying a promising rock type on a map and taking a few grab samples. Many other geological parameters can affect the quality of the stone or the suitability of the site for development. These can include harmful mineralization, shearing, microfracturing, weathering, interbedded deleterious rock types, overburden depth or alkali-aggregate reactivity. Costly mistakes can be avoided if the exploration for aggregate is approached in a methodical, scientific manner similar to any other mineral commodity.

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Dalhousie University: Department of Earth Sciences Student Research in Nova Scotia

by ***P. H. Reynolds***, Chair, Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Phone 902-494-2358, or check us out at http://meguma.earthsciences.dal.ca/

Dalhousie University in Halifax is well situated and well equipped for research in a range of Earth Science disciplines. The department includes 11 full-time faculty members and 6 university technicians, with 15 Ph. D., 10 M. Sc. and 11 B. Sc. honours students (final year) registered in 2000-2001.

The department offers research projects in petrology and geochemistry, sedimentary geology, micropaleontology, tectonics, structural geology, and in thermochronology (argon, fission track and thermal luminescence/optical dating). Many faculty members and their students are involved in research in Nova Scotia or its adjacent continental margin. Research is funded largely through the Natural Sciences and Engineering Research Council (NSERC), other government agencies, and contracts; most graduate students hold scholarships or fellowships paid from university and/or research funds.

Research equipment includes a JEOL 733 electron microprobe* with image analysis system (run as a regional facility); geochronology laboratories: (i) conventional and laserprobe $^{40}Ar/^{39}Ar$ dating, (ii) thermally and optically stimulated luminescence (TOSL) research, (iii) fission track research; X-ray diffraction equipment, a high pressure seismic velocity lab, and a wide range of geophysical, sedimentological, micropaleontological, computing, petrographic, sample preparation, and photographic equipment.

*Major funding for a new microprobe facility was acquired from NSERC earlier this year.

Student Thesis Research in Nova Scotia, Theses Completed in 2000

M. Sc.

Johannessen, Duncan, 2000.
Multi-isotope Geochemistry of Surface and Groundwater in the Avon River Drainage: Hydrogeological Implications

B. Sc. Honours

Costain, Tanya, 2000.
Stratigraphic Analysis and Possible Tidal Influence in the Thorburn Member and Coal Brook Member, Stellarton Formation, Nova Scotia. 83 p.

MacDonald, Shannon, 2000.
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Ore deposits in the New Ross area.

A. M. Ryan (Ph. D.):
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An Example of Celestite and Galena Deposition in a Modern Solution Karst Trench Environment at Beckwith, Nova Scotia: Implications for Deposit

Modelling

by ***R. J. Ryan***, rjryan@gov.ns.ca and ***D. J. Kontak***, kontakdj@gov.ns.ca

The Beckwith celestite occurrence is located 6 km south of Port Howe in Cumberland County. The occurrence was discovered in 1911 and has experienced episodic exploration over the last ninety years. The celestite occurs within grey and red clays near the contact between sandstones, siltstones and pebble conglomerates of the Cumberland Group and evaporites and clastics of the Windsor Group. There is clearly a faulted contact between the early Carboniferous Windsor Group and the surrounding late Carboniferous Cumberland Group strata. In the Cumberland Basin the Windsor Group evaporites occur associated with salt-cored diapiric structures. Celestite and minor associated galena occur as isolated pods and disseminations within unconsolidated clays, which are interpreted herein as relatively young karst-fill residuum material. Celestite can be seen to displace the host clay and appears to be growing ***in situ***. The mineralization occurs as sand-size blebs in the clay and also as pods of almost pure celestite up to 6 m in length. Galena occurs as small (5 mm) crystals growing on the celestite blades. Gypsum and anhydrite of the Windsor Group contain a high content of strontium, with up to 14 000 ppm and an average of 990 ppm based on 87 analyses throughout Nova Scotia. On average, anhydrite contains more strontium than the hydrated equivalent gypsum, suggesting that strontium is liberated during the hydration process. Dissolution of the gypsum during karstification would liberate additional strontium and, therefore, water within the karst system should contain a significant content of strontium. The current research is focused on the geochemistry of water in the pit area, the geochemistry of the gypsum and anhydrite, fluid inclusions in the celestite, and palynological dating of grey clay from the pit. If the preliminary conclusions based on the morphology of the deposit are found to be substantiated by these additional studies, then it is evident that the mechanism of solution trench concentration of elements is active currently at Beckwith and that karstification may be responsible for similar mineralization elsewhere in time and space.

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Mercury Contents of Surface Waters, Kejimkujik Park Area, Nova Scotia

by ***A. L. Sangster***, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, ***G. Hall***, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8 and ***P. K. Smith***, pksmith@gov.ns.ca

Samples of water and rock from the Kejimkujik National Park area are being collected for Hg analysis as part of the multidisciplinary TSRI (Toxic Substances Research Initiative) Project funded by Health Canada. This abstract deals only with the water component of the study.

Water samples are collected from drainage courses with an emphasis on source tributaries. At each sample site 3 x 60 ml water samples are collected in HDPE bottles using a 50 ml syringe equipped with a Sterivex-HV, 0.45 µm filter cartridge. The sample for Hg analysis is stabilized with 1 ml EPA standard BrCl (Br_2, HCl) solution and a sample for cation analysis is treated with 0.5 ml ultrapure 8 M HNO_3. A sample for anion analysis contains no additives. Only the Hg results will be discussed here.

Drainage character in the area is highly variable and dependent on till type. In areas dominated by very porous till derived from granitic rocks, much of the drainage is subsurface with few surface streams as well as streams that flow on surface for a few tens or hundreds of metres then disappear. In the dry period in August of this year, most of the smaller streams and bogs in these areas were dry. In areas of more clay-rich till derived from Halifax Formation rocks, streams are regular and predictable and support a much more consistent water flow.

Partial results to date (138 of 216 samples) indicate that Hg levels vary from the detection limit of 0.5 ppt (yes, that is parts per trillion) to a high of 17 ppt. No single anomalous mercury source has been found and the range of analyses seems to indicate:

- Levels in small tributaries are higher than those obtained in larger streams, indicating a loss of Hg down drainage, probably to the atmosphere.
- Waters containing high DOC (dissolved organic carbon) tend to contain the highest Hg levels.
- Many of the higher values occur in streams over the sulphidic-carbonaceous Halifax Formation rocks or in very low pH (3.8 to 5.0) streams draining the Kejimkujik granite.

Reference

Sangster, A. L. 2000:
Litho- and hydrogeochemistry of Hg in the Kejimkujik Park area, Nova Scotia; in Multidisciplinary Study of Metal Cycling, Primarily Hg, in Aquatic and Terrestrial Environments, eds. N. O'Driscol, A. Rencz and T. Clair; First Workshop Proceedings of Kejimkujik Toxic Substance Research Initiative Work Group; Environment Canada-Atlantic Region, Sackville, New Brunswick, Occasional Report no. 15, p. 34-36.

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Gravity Investigation of a Possible Mineralization-related Granitic Intrusion Under the Kennetcook Basin

by ***D. F. Sangster***, 2335 Russvern Drive, North Gower, Ontario K0A 2T0, and ***M. D. Thomas***, Geological Survey of Canada, 615 Booth Street, Ottawa, Ontario K1A 0E9

The Carboniferous Kennetcook Basin coincides with a prominent negative gravity anomaly attaining a peak amplitude of about -25 mgal relative to the general background level of the gravity field to the west, north, east and southeast. South and southwest of the anomaly the gravity field falls off dramatically over the South Mountain Batholith. The nature of the source of the low has a critical bearing on the development of mineralization along the northern margin of the basin. If the low can be linked to a buried granite, which happens to be a high-heat-producing (HHP) granite, mineralization may be attributed to thermally driven convection of mineral-bearing fluids. Studies indicate that radioactive heat from solidified HHP granites has the necessary potential to sustain a hydrothermal convection system capable of generating uranium deposits through circulation of meteoric water. A similar scenario has been proposed to initiate convection of basinal brines, thereby playing a fundamental role in the formation of certain stratabound lead-zinc deposits. HHP granites having heat flows ranging from about 59 to 79 mWm^{-2} are known to occur in nearby areas of Nova Scotia and southern New Brunswick, one of which is the South Mountain Batholith. The presence of buried HHP granites south of the Kennetcook Basin, within lower Palaeozoic rocks of the Meguma Group, has been proposed on the basis of similar high heat flow values because rocks belonging to the group itself produce very low heat flows (2 mWm^{-2}).

This study in progress examines the possibility that a significant component of the Kennetcook Basin gravity low is related to a HHP granitic intrusion. However, there is some evidence, based on the distribution and pattern of the low, to indicate that the sedimentary basin may be the principal source of the low. The evidence includes the close spatial correspondence between the northern margins of the Horton Group and the gravity low, and between the southern margins of the basin and gravity low. There is also an overall similarity in the pattern of contours defining the flanks of the anomaly and the perimeter of the Windsor Group. If the sedimentary basin is totally responsible for the gravity low, it must be demonstrated that the sedimentary fill has the requisite thickness and density to generate a -25 mgal amplitude anomaly. The Windsor Group, and to a lesser extent the Horton Group, are hosts to salt deposits, which generate substantial negative anomalies. For example, many salt deposits within the Kennetcook, Shubenacadie-Stewiacke and Cumberland basins are associated with negative anomalies (>-5 mgal amplitude, and several are >-

10 mgal). In some cases, the lows are obviously directly attributable to the density contrast between salt (2.16 g/cm^3) and the enclosing Carboniferous sedimentary rocks (individual units range from about 2.17 to 2.82 g/cm^3; a weighted mean density for almost 1000 m of Windsor Group rocks is 2.67 g/cm^3). In other cases the lows are probably a combination of the effects of low density salt, and low density Carboniferous sedimentary rocks contrasted with higher density basement rocks assigned mainly to the Ordovician Halifax Formation.

The effect of salt on the gravity field is particularly evident along the southeastern margin of the Kennetcook Basin, where the gravity low associated with the basin attains its maximum amplitude. Here an elongate, shorter wavelength, trough-like negative anomaly, extending approximately from the village of Stanley to Kennetcook, is superposed on the overall low that coincides with the entire basin. It is related to a body of salt that has been referred to as the Clarksville occurrence, and it has an estimated amplitude of about -11 mgal, based on a published gravity profile and geological section. If this is a realistic value for the contribution of salt, then it means that approximately -14 mgal of the -25 mgal amplitude of the basin must be related to the non-salt portions of the sedimentary succession and/or a buried granite. Several cross-sections of the Kennetcook Basin, controlled by seismic data in some places, are analyzed for their contribution to the gravity field, and the issue of a possible buried granite is addressed through presentation of several gravity models.

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Slate Potential in Kings County

by ***P. K. Smith***, pksmith@gov.ns.ca

In 1927, J. P. Messervey published a monograph documenting some of the slate potential in Nova Scotia (Messervey, 1927). Of the five occurrences mentioned, three occur in Kings County between New Minas and North Alton. One quarry at North Alton was operated by R. M. Keirstead of Alton Slate Quarries Ltd. At this location approximately 1.3 x 2.0 m, flawless blocks of variegated slate were excavated from a working face measuring approximately 3 x 5 m. Messervey noted that: "This material is excellent for milled slate work and can be easily matched for tile work and other inside finish".

A second property is located at Moore Falls on Moore Brook approximately 100 m north of Highway 101. Although there was no development of this material, Messervey states: "... it can be classed as first class quality, i.e. hard metallic ring, easily cleavable, fairly smooth surface, punches well, no water adsorption, clay odor, sulphide, quartz inclusion of ribbons". This grey to reddish to blue slate belongs to the east-trending, lower Paleozoic Halifax Formation which underlies much of the region.

The third property is located on the west side of the road between New Minas and White Rock, about 1.6 km from New Minas, and was owned by Acadia Slate Co. The belt is approximately 300 m wide and the slates exhibit a hard metallic ring and are cleavable down to approximately 2 mm. Cleavage and bedding are parallel in these lower Paleozoic, grey rocks. In his pamphlet, Messervey references a Mr. Jones, who had experience in other slate quarries in Wales and Vermont and states that, "this slate is as good as the best and that it can be quarried cheaper than foreign slates". He further states "... there is evidence enough to indicate a very large body of first-class material".

During a follow up to Messervey's documentation, this author visited and collected representative slates from the lower Paleozoic Halifax, Kentville and White Rock formations in the New Minas area (Table 1). In addition, the author constructed a 35 m long x 1 m high slate retaining wall as well as a 40 m^2 patio walkway from a local supply of Halifax Formation slate. Mixed slates from these three formations represent a range of colours from light grey to grey-blue, mixed grey and red, and dark blue to black. Cleavage parting ranged from poor to excellent with 1 m^2 slabs breaking into pieces from <0.5 mm to approximately 3 cm thick. In general, the sandier rocks produced thicker slabs. Several rocks produced a hard metallic ring, and most were free of inclusions and sulphide.

As the demand for high quality, affordable stone products increases throughout the region, so does the potential for the economic operation of a stone quarry. The local availability of high quality slate in addition to proximity to both local and export markets should help support the viability of a local industry for this commodity.

Reference

Messervey, J. P. 1927:
Slate in Nova Scotia, Nova Scotia Department of Public Works and Mines, Monograph Pamphlet No. 26, 15 p.

Table 1. Description of samples collected in 2000 near New Minas.

Sample #	Lithology	(NAD 27) Easting	(NAD 27) Northing	Color	Texture	Parting (cm)	Overall Quality*
NMS00-01	Slate	381254	4989360	Blue/Grey/Red	Ripple Marks	0.3	High
NMS00-02	Slate	378789	4990399	Black	Parallel Laminations	1-10	Low
NMS00-03	Slate	384172	4987434	Black	Fissile	0.5	Medium
NMS00-04	Slate	384169	4989852	Green/Grey/Red	Mottled	0.3	High
NMS00-05	Slate	385878	4990249	Lt. Grey/Lt. Pink	Mottled	0.5	Low
NMS00-06	Slate	385919	4990235	Olive grey-green	Soft Pastel	0.2	Medium
NMS00-07	Slate	388575	4990010	Dark blue	Mottled	0.2	High
NMS00-08	Slate/Silt	389509	4987575	Blue/Grey	Ripple Marks	2-5	Medium
NMS00-09	Slate/Silt	389799	4987166	Dark blue-grey	Thinly Laminated	2-8	Medium
NMS00-10	Siltstone	389875	4986582	Blue-grey	Dense (sulphide)	2	Medium
NMS00-11	Slate/Silt	389827	4986701	Dark blue-grey	Cross Laminations	2-5	Medium

*Based on field observations only.

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Meguma Gold: Then, Now and the Future

by ***P. K. Smith***, pksmith@gov.ns.ca and ***L. J. Ham***

The Meguma Group of southern Nova Scotia has gained world attention for its quartz vein style of gold mineralization and its similarity to the Victoria gold province of Australia. Notwithstanding the geological

similarities, there are several important differences between the two regions. First, Victoria has had a long and prosperous history of placer gold development. It was the discovery of gold at Ballarat in 1851 that resulted in Victoria's gold boom. In fact, Ballarat was recognized as the richest alluvial goldfield in the world at its peak between 1852 and 1853. In large part this activity fuelled subsequent underground developments. Second, underground development and mining in Victoria has been undertaken to considerable depths (>1500 m), whereas development in the Meguma has never exceeded 320 m. Hence, there is a much higher confidence level in the geological controls to ore mineralization in Australia. Last, and perhaps most important, there is a belief among geologists and developers that there is true potential for economic gold deposits in Victoria, whereas there is frequent scepticism regarding similar opportunities in Nova Scotia. However, a direct comparison of grade and ore extracted per vertical cubic metre of underground development within the two regions indicate that they are essentially identical. Given this comparison, why there has not been more extensive development in Nova Scotia?

Currently, there are no active gold mines in the Meguma Terrane. However, the Dufferin extension and the Tangier district are presently being investigated with hopes to bring both into production in the near future. Dufferin represents a classic saddle reef style deposit with the highest gold grade nearest to the fold hinge (similar to some Australian deposits), while the Tangier deposit is a bedded, lode gold deposit with multiple plunging ore shoots along individual quartz veins, localized in at least three separate ore zones along strike.

Several additional deposits have strong potential for development. These include, but are not limited to, Forest Hill, Upper Seal Harbour, Fifteen Mile Stream, Beaver Dam, Mooseland, Moose River, Caribou and Molega. These, and others, are currently awaiting the appropriate financial climate to favour production.

A crystal ball is required to see what lies in the future for Nova Scotia's numerous gold deposits. Although there should be no question regarding the favourable geological environment for gold (and other metals), it is critical that all pertinent data be made available pertaining to the geology of these deposits so that exploration and development companies may make efficient use of investment funds. To this end, a five-year project has been undertaken by the department to compile and synthesize both public and obscure information related to the geology and mineral occurrences in the Meguma Terrane of eastern Nova Scotia. This study includes a 1:50 000 scale geological compilation, as well as data compilation and synthesis of selected gold deposits. These data are being collected from the libraries of NSDNR, Atlantic universities, the Geological Survey of Canada, and from unpublished information held by private companies and numerous scientific researchers. The products will be published as a series of 1:50 000 scale maps, selected database tables, brochures and manuscript papers. Most information will be available in both digital and hard copy formats.

It is hoped that the resulting information will assist both the private (e.g. companies, consultants, researchers) and public (e.g. government researchers, schools, universities) sectors, as well as providing background information for a number of environmental issues. As always, geological investigation of mineral deposits is carried out with the ultimate goal of allowing efficient use of the province's natural resources.

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Mercury Recycling in the Environment: Whole Rock Geochemistry in Kejimkujik National Park, Nova Scotia

by ***P. K. Smith***, pksmith@gov.ns.ca and ***A. L. Sangster***, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

Earlier documentation (Mercury in Atlantic Canada, A Progress Report, 1998) of fish and loons in Kejimkujik National Park noted elevated Hg levels in blood. In May 1999, a three year multi-disciplinary research project was

initiated under the Toxic Substances Research Initiative (TSRI) funded by Health Canada. The primary objectives are: (1) to determine the relative contribution of atmospheric deposition, geological sources, and geochemical, biological and photochemical processes on mercury concentrations in aquatic and terrestrial systems in Kejimkujik Park, and (2) to investigate the significance of factors that control the bioavailability of metals, particularly Hg, in the aquatic and terrestrial environment in an area known to have high metal levels.

Data are being collected on geology, water, lake sediments, vegetation, bacterial and mercury cycling in the park to determine baseline concentrations for major and trace elements (including Hg) and processes responsible for Hg toxicity. It is hoped that this study will delineate the magnitude of the problem at Kejimkujik National Park and in addition, establish a reference data set to evaluate other regions in eastern Canada.

In 1998, 118 bedrock samples were collected for Hg and selected major and trace element analyses. During the 1999 field season, a total of 146 additional sample were analyzed for their Hg content and, of these, 72 were analyzed for trace and major elements. All analyses were carried out under a GSC contract by ACME Analytical Laboratories Ltd. in Vancouver. These samples included representative rock types both inside and outside the park, encompassing lower Paleozoic to Triassic units (Goldenville, Halifax, White Rock, Kentville and Torbrook formations and the North Mountain Basalt). A summary of the Hg data is shown in Figure 1 below. The highest average mercury levels were encountered in biotite separated from selected granites (13.8 ppb) followed by two samples of Silurian strata located north of the park (12.2 ppb). A full working data set is published in CD format as TSRI Mercury Research Project, Version 1.0, ISBN 0-662-29241-3.

In 2000, an additional 67 bedrock and boulder samples were collected from remote areas inside the park and at previously sampled location to verify earlier results. Of these nine samples of biotite-rich granitoids were collected for mineral separation and analysis. Where possible, these samples were collected adjacent to glacial till sample sites (see Goodwin, this volume). Results of this year's work, as well as that of other team researchers, will be published in both hard copy and CD versions in early 2001.

Other collaborative researchers associated with geological aspects of this project include: T. A. Goodwin (glacial till investigation), A. M. O'Beirne-Ryan (paleo-weathering geochemistry) and K. Page (bedrock-till element mobility).

Figure

Figure 1. Average mercury concentration (ppb) in various rock types.

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Investigations of Petrologic Controls on Trace Element Concentrations in the South Mountain Batholith, Southern Nova Scotia

by ***C. R. Stanley***, Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0, cliff.stanley@acadiau.ca and ***C. H. Giles***, Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0

The South Mountain Batholith is the largest granitoid in the Appalachian Orogen and 'host' to the East Kemptville tin deposit. Emplacement took place in two stages during the Devonian; the first stage consisted largely of biotite granodiorite and monzogranite, and the second stage consisted of muscovite-biotite monzogranite, leucomonzogranite and muscovite monzogranite. In addition to the common mineralogy of these granites (quartz, alkali feldspar, plagioclase, biotite and muscovite), accessory minerals indicating peraluminous affinities (aluminosilicate, cordierite,

garnet, tourmaline and topaz) and ilmenite are present.

In spite of the largely igneous origin of the major rock-forming minerals, significant amounts of hydrothermal alteration have been identified in large parts of the batholith, and this alteration likely controls at least some of the trace element concentrations observed. In order to investigate to what extent igneous and hydrothermal processes control the abundances of several, economically interesting trace elements (Sn, F, Li, W, Ta) in the batholith, the Nova Scotia Department of Natural Resources lithogeochemical database, consisting of over 600 whole-rock major and trace element analyses of samples from the batholith, was investigated. Detailed data analysis was undertaken on samples within the Halifax Pluton using molar element ratio analysis. Controls on major element concentrations were modelled using Pearce element ratio diagrams that test quartz, alkali feldspar and plagioclase fractionation hypotheses. Muscovite control has also been documented, although its involvement is interpreted to be a consequence of widespread sub-solidus deuteric alteration, rather than igneous fractionation. To date, biotite fractionation does not appear to be required to explain the major element compositional variations.

With knowledge of the predominant mineralogical controls in the batholith, Pearce element ratios have also been derived that isolate the fractionation effects caused by these major minerals. Plotting these ratios against trace element abundances allows determination of the nature and extent of control of the trace elements by major mineral fractionation. Slopes of the linear trends observed on these plots can be used to determine bulk mineral-melt distribution coefficients, and anomalous samples with concentrations that cannot be explained by simple fractionation can also be identified. Because these anomalous samples have probably been influenced by hydrothermal alteration, the residuals between these anomalous samples and the linear (fractionation) trends on these diagrams describe the extent of addition or loss of the trace element during hydrothermal alteration. Plotting these residuals in space allows recognition of where within the South Mountain batholith trace element concentrations have been significantly enriched or depleted. Thus, these plots identify prospective areas for hydrothermal mineral deposits within the batholith.

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Surficial Geology and Geochemistry of the Main Line and the Halifax Lateral Natural Gas Pipelines, Nova Scotia

by ***R. R. Stea*** and ***T. A. Goodwin***, goodwita@gov.ns.ca

During the summer of 1999, a 230 km long trench averaging 3 m in depth was excavated from Goldboro, Guysborough County, to the New Brunswick border prior to the installation and burying of Nova Scotia's first natural gas pipeline (Main Line). The gas originates from offshore Nova Scotia and is destined for markets in eastern Canada and the northeastern United States. A second trench (Halifax Lateral) approximately 125 km in length was excavated from Pictou County to Dartmouth during the summer of 2000. This section of the pipeline will bring natural gas to businesses and homes in the Halifax-Dartmouth metropolitan area. Once all safety requirements with respect to working around open trenches were met, Maritimes and Northeast Pipelines granted permission to the Nova Scotia Department of Natural Resources to map the surficial geology of the trenches and to remove sample material.

The surficial geology of the Main Line and the Halifax Lateral was mapped in 1999 and 2000, respectively. Surficial units were broadly classified with respect to overburden type (e.g. ablation till, till blanket, till veneer, bedrock-dominated till, sand and gravel, etc.) and associated landform features (e.g. drumlin, kame, etc.). Locally, more than one till unit was noted and at several locations a distinct peat layer separated two till units. The peat layer was mapped and sampled for subsequent age determination.

Samples for geochemical analysis were collected approximately every 500 m along the entire length of both trenches.

During sampling of the Main Line in 1999, 10 kg till samples were routinely collected at each sample site. However, during sampling of the Halifax Lateral in 2000, a 5 kg sample and a separate 500 g sample were routinely collected at each sample site. Strict quality control protocols were adhered to during collection of the samples in the field and during laboratory preparation and analysis.

All samples will be analyzed for Au, Hg and multi-element geochemistry (<63 microns fraction). To date, only samples from the Main Line have been analyzed. These data are currently being assessed and prepared for release as an Open File Report. Samples from the Halifax Lateral were recently collected and it is anticipated they will be prepared and analyzed during the fall of 2000. Future processing of the bulk till samples may include preparation of heavy mineral concentrates, mineralogical descriptions and clast counts. All sample material is currently being stored at the department's core library in Stellarton.

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Stratigraphy and Structure of the Horton Group in the Lochaber-Mulgrave Area, Nova Scotia

Funded by a Natural Sciences and Engineering Research Council of Canada Research Grant to S. M. Barr and by the Nova Scotia Department of Natural Resources

by ***P. J. Ténière***, Department of Geology, Acadia University, Wolfville, Nova Scotia BOP IXO, ***S. M. Barr***, Department of Geology, Acadia University, Wolfville, Nova Scotia BOP IXO and ***C. E. White***, whitece@gov.ns.ca

The Lochaber-Mulgrave region of Nova Scotia contains geological units that have been tentatively assigned to the Carboniferous Horton Group. However, the area is structurally complex and, compared to other parts of the Horton Group, the rocks are generally more deformed and cleaved. Although a preliminary stratigraphy has been proposed in the area, its validity is uncertain because of structural complexity. For example, some units in the Lochaber area have been previously assigned to the Early Devonian part of the Arisaig Group. Hence, a detailed mapping, stratigraphic and structural study of the area has been initiated as a M. Sc. thesis project at Acadia University.

The Lochaber-Mulgrave study area is bounded by the Glenroy Fault on the north, the Strait of Canso on the east, the Roman Valley Fault on the south, and pre-Carboniferous rocks of the Antigonish Highlands on the west. The field work will build on data collected during earlier mapping in the area, on the basis of which the Horton Group was divided into three formations: (1) Clam Harbour River Formation, (2) Tracadie Road Formation, and (3) Caledonia Mills Formation. The Clam Harbour River Formation consists of light grey to green to maroon quartz arenite and siltstone, grey to black laminated siltstone, and polymictic pebble to boulder conglomerate. The Tracadie Road Formation is composed of grey to black laminated siltstone interlayered with grey, fine- to coarse-grained quartz arenite. Pebble conglomerates are common and matrix supported with clasts of quartzite, siltstone and other sedimentary rocks. The Caledonia Mills Formation consists of red to maroon siltstone and fine sandstone, with minor quartz arenite, conglomerate and limestone. Fine-grained sandstone and siltstone beds are locally well laminated and contain cross-stratification. Grey to red polymictic conglomerates are rare and can contain volcanic, sedimentary and granitoid clasts. Green to grey laminated siltstone is commonly interbedded with the maroon siltstone.

In much of the area, this sequence of units appears to be gradationally conformable, with the Caledonia Mills Formation being the youngest. However, in the western part of the area, between South River and Lochaber Lake, younging directions are not everywhere consistent with this interpretation. Hence, as a first phase of the project, preliminary field mapping in the late summer and fall of 2000 concentrated in this area, with the goal of unravelling the stratigraphy and structure in more detail. The Caledonia Mills Formation in the map area consists of a lower, red to maroon, fine-grained, laminated, cleaved siltstone and slate unit, overlain by greenish-grey massive to well laminated, cleaved siltstone and slate, interbedded with grey quartz arenite beds. The relationship of these units to the adjacent (and apparently overlying) Tracadie Road Formation is as yet unclear. Bedding in the area is generally steep

and trends northeast; however, the distribution of the mapped units suggests a more complex, possibly polyphase, history of folding. Although orientations suggest that the cleavage is axial planar, considerable variation indicates the possibility of re-folding. Minor, shallow-plunging, isoclinal folds near the eastern and western sides of the area may be related to the Lochaber and South River faults.

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Petrology and Age of the Cape Porcupine Complex, Guysborough County, Nova Scotia

Project funded by Nova Scotia Department of Natural Resources and a Natural Sciences and Engineering Research grant to S. M. Barr

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Cape Porcupine, a prominent hill adjacent to the Canso Causeway, was quarried to provide rock for the construction of the causeway, and quarry operations continue at the present time. This study was undertaken to describe the rock types that form Cape Porcupine, determine their age, and compare them to other "basement" rocks in northern mainland Nova Scotia and adjacent parts of Cape Breton Island.

Cape Porcupine consists of varied igneous and metamorphic rocks named the Cape Porcupine Complex. The rocks of the complex are in faulted contact on the north and west by conglomerate, sandstone and slate of the Clam Harbour River Formation, assigned to the Horton Group. However, the southern margin of the hill seems to be unconformably overlain by the Clam Harbour River Formation, as indicated by a basal conglomerate that contains clasts of rocks from the complex. The Cape Porcupine Complex is divided into four map units. The western unit, in the area of the quarry now operated by Martin Marietta Limited, consists mainly of varied granitoid rocks, ranging from granite to diorite, with abundant metavolcanic xenoliths of mainly andesitic composition. The rocks are intruded by several generations of variably altered mafic dykes, youngest of which contain fresh clinopyroxene. The central part of the complex consists of mylonitic metasedimentary rocks, trending approximately north, with steep dips and a shallowly north-plunging lineation. Their contact with the granitoid unit, at least locally, appears to be a brittle thrust or reverse fault dipping to the west, with the granitoid rocks thrust over the mylonitic metasedimentary rocks. The metasedimentary rocks consist of quartz, plagioclase, chlorite, epidote and abundant muscovite. On the east, the mylonitic metasedimentary unit is in faulted contact with a mylonitic felsic tuffaceous unit. The fault is vertical and trends approximately north-south, parallel to the mylonitic fabric in both units. The felsic mylonite contains abundant quartz ribbons and K-feldspar augen in a fine-grained quartz-feldspar groundmass. The rocks display a strong north-trending subhorizontal lineation. The easternmost unit of the complex is not well exposed but appears to be dominated by mylonitic granite, with post-mylonite mafic dykes.

To better constrain the age of the Cape Porcupine Complex, the dominant granitic unit in the Martin Marietta quarry was sampled for dating. This granitic unit appears to be the youngest granitoid component of the western unit of the Cape Porcupine Complex. It consists of coarse-grained quartz, K-feldspar and plagioclase. The sample yielded a single population of colourless, euhedral to subhedral, doubly-terminated zircon prisms, most of which contain minor solid and fluid inclusions and cracks. The best quality grains lack inclusions and cracks but are not abundant. Three abraded zircon fractions plot as a slightly discordant cluster with $^{207}Pb/^{206}Pb$ ages of 609-613 Ma. Because the precise age of these fractions is somewhat ambiguous, a fourth fraction of best-quality, strongly-abraded grains was analyzed. This fraction yields a concordant age of 608±6 Ma. However, in considering the range of all $^{207}Pb/^{206}Pb$ ages, the ±6 Ma uncertainty appears to be somewhat high for the sample age. We instead prefer to cite an age of 610±3 Ma for the Cape Porcupine granite, which spans the range of $^{207}Pb/^{206}Pb$ ages of all fractions.

We postulate that the mylonitic metasedimentary and felsic rocks mark the location of the Canso Fault. The rocks of Cape Porcupine are similar in age to some units in southeast Cape Breton Island, but older than the granites of the Creignish Hills. They are also similar in age to some granitoid units in the Antigonish Highlands.

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Geology of the Southwestern Meguma Terrane, Nova Scotia

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Detailed mapping in the Meguma Terrane, from Digby to Shelburne, was initiated in 1998 by the Nova Scotia Department of Natural Resources. The purpose of the project is to produce a series of updated, 1:50 000 scale geological maps of the area, which may be used as a framework for mineral exploration.

The oldest units in the map area are the Cambrian to Ordovician Goldenville and Halifax formations. The Goldenville Formation consists of grey, massive to locally laminated metasandstone, interbedded with minor metasiltstone, slate and conglomerate. Carbonate concretions are common. Rare trace fossils have been observed, but not assigned an age. The overlying Halifax Formation has been divided into five informally defined members: Bloomfield (maroon and green metasiltstone to slate), Acacia Brook (grey, slate with minor metasiltstone and metasandstone), Cunard (black, sulphide-rich slate and metasiltstone), Bear River (grey, silty slate with minor metasiltstone, slate and metasandstone), and Sissaboo River (laminated green-grey metasiltstone and slate). Early Tremadocian graptolites have been recovered from near the top of the Bear River member. $^{40}Ar/^{39}Ar$ ages from detrital muscovite samples from the Digby area yield a provenance age of ca. 550 to 600 Ma for the Goldenville and Halifax formations.

The overlying White Rock Formation is well exposed in the Digby and Yarmouth areas. The contact with the underlying Halifax Formation in the Digby area is a disconformity or angular unconformity; however, in the Yarmouth area it is faulted. In the Digby area the formation consists of grey slate, metasiltstone, and a distinct thick (<30 m) metasandstone layer. Late Silurian fossils have been collected near the top of the formation. Detrital $^{40}Ar/^{39}Ar$ muscovite ages suggest detritus from a ca. 500 Ma source area. In the Yarmouth area, the White Rock Formation is composed of metavolcanic and metasedimentary rocks interpreted to be intruded by the granitic Brenton Pluton. Mafic volcanic rocks of the formation have alkalic affinity and a within-plate tectonic setting. The felsic volcanic rocks and the Brenton Pluton have some characteristics of within-plate A-type granites. U-Pb dating from a felsic volcanic unit yielded an age of ca. 438 Ma.

Conformably overlying the White Rock Formation in the Digby area is the Torbrook Formation. It consists of grey metasiltstone, slate, metasandstone, marble, and rare ironstone. Early Devonian shelly fossils are common. Numerous mafic sills intrude all the above units. A conformable sequence of Triassic to Jurassic sedimentary rocks (Wolfville and Blomidon formations) and basalt (North Mountain Formation) unconformably overlies the older units.

The lower to middle Paleozoic units and sills were deformed during the Devonian Acadian Orogeny into regional NE- to NNE-trending, moderately plunging folds with axial planar cleavage. Metamorphism associated with the Acadian Orogeny was at greenschist facies; however, in the southwest metamorphism reached amphibolite facies. The ca. 370 Ma South Mountain Batholith and related plutons intruded the older units and produced contact metamorphic aureoles with abundant andalusite and cordierite superimposed on regional fabrics. An intense crenulation fabric in

the Bloomfield, Acacia Brook and Cunard members clearly reflects post-Acadian deformation. $^{40}Ar/^{39}Ar$ data suggest that the ca. 400 Ma Acadian Orogeny occurred immediately after deposition of the Torbrook Formation and was near completion prior to intrusion of the South Mountain Batholith. The intense crenulation is Carboniferous in age and postulated to be related to strike-slip movement along the terrane-bounding Cobequid-Chedabucto Fault System. It may record final docking of the Meguma Terrane against North America.

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Information Management Initiatives at GSC Atlantic and Nova Scotia Department of Natural Resources

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The transformation to a connected, on-line public service is accompanied by many substantive technological and human resource challenges. Associated incremental changes are fundamentally altering the fabric of government and the nature of governance itself. The way public servants see their roles, conduct their business, and the way they are viewed by the clients they serve reflect just a few of the changes underway. How are these changes influencing the federal and provincial geoscience agencies? What can and should these agencies do to maximize contributions to these developments? What opportunities do they present for more effective and efficient performance and delivery of science programs and for interlinkage with other, federal, provincial and municipal levels of government?

Answers to these and other questions are not straightforward. What is clear, however, is that government science and technology organizations like the GSC Atlantic and the Nova Scotia Department of Natural Resources (DNR), are at the sharp end when it comes to generating the new data, information and knowledge necessary to bring meaning to the term "connected Canadians". This display provides a snapshot of some current GSC Atlantic and DNR initiatives that set out to digitally gather and archive geoscience information and that are developing mechanisms to allow effective (content issue) and efficient (speed issue) access.

GSC Atlantic's efforts are interlinked with national efforts and should be viewed within the framework of NRCan's Earth Science Sector, GeoConnections, CGKN (Canadian Geoscience Knowledge Network) and GOL (Government on Line) initiatives. GSC Atlantic staff are involved in the development of a national information management infrastructure as well as adopting and implementing standards, systems and methodologies.

DNR is focusing its efforts on providing its data to clients as free downloads through the Mineral Resources Branch web site (http://www.gov.ns.ca/natr/meb/pubs/pubs3.htm) and developing an Internet map server to allow clients to work with the data. DNR is also a partner with the Geological Survey of Canada on the Canadian Geoscience Knowledge Network initiative.

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